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**ADOLESCENT DRINKING PATTERNS
ASSOCIATIONS BETWEEN ALCOHOL CONSUMPTION AND NEUROPSYCHOLOGICAL
DEVELOPMENT**

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**‘ADOLESCENT DRINKING PATTERNS:
ASSOCIATIONS BETWEEN ALCOHOL
CONSUMPTION AND
NEUROPSYCHOLOGICAL
DEVELOPMENT’**

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Abstract

Background and rationale: Adolescence presents a unique time of neurodevelopment, whereby the use of alcohol may have detrimental consequences for brain structures and neurological functioning. Adolescent drinking patterns have been largely formulated using measures designed for adult populations, which may lack the fine-grained characterisations, which might theoretically more likely lead to neuropsychological impairment in this group.

Methods: This study explored the prevalence and nature of alcohol use drawing from the SIPS Junior research programme (n=5576) a screening and prevalence survey of alcohol consumption in adolescents (10-17yrs) attending Emergency Departments in England and IMAGEN, (n=1557) a European research project examining risk taking behaviours in teenagers (14yrs). Metrics of alcohol use were formulated into latent class structures aimed to represent the heterogeneity of drinking behaviours. Associations between latent classes and a range of outcomes of harm and neuropsychological function tasks were examined.

Findings: Results revealed 39.3% of SIPS Junior participants had consumed alcohol in their lifetime and had a mean age of onset of 12.88 years (SD 2.19). A total of 76.6% of IMAGEN participants reported having ever consumed alcohol and revealed a mean age of onset of 12.44 years (SD 1.02). Subgroups characterised by beverage type consumption were associated with varying levels of risk of harms with observed differences between genders. In addition, latent classes characterised by unit consumption, onset, intoxication, AUDIT-C scores and drinking days in both data sets and across all countries were examined. Varying levels of harm were associated with class membership demonstrating observed differences between genders. IMAGEN results revealed differences in neuropsychological functioning tasks involved in attention and memory in adolescents identified as higher risk drinkers.

Conclusions: Adolescents, characterised by a limited number of drinking indicators were found to be associated with a range of harms and neuropsychological function tasks. Latent class formulations offered insight as to how these drinking typologies may present neuropsychologically at a time when a young person may be making decisions around their future course.

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Declaration

I declare that I designed and conducted the research reported in this thesis and that it has not been submitted for a degree in this, or any other institution. During the course of this programme I was a member of the SIPS Junior Project Team and while data obtained from both the SIPS Junior and IMAGEN research programmes were not collected personally, data was cleaned, recoded and analysed myself for the purpose of this thesis. To the best of my knowledge, this thesis does not contain material that has been published or written elsewhere by another person, except where acknowledgment and due reference is made in the text.

Chapter 1 Introduction

1.1 Global Burden of Disease Attributable to Alcohol Use

From the 3.3 million deaths globally each year to the estimated annual £10 billion the UK Government receives from alcohol duties (ONS, 2013) the debate over the benefits and costs of alcohol shows no signs of abating.

In more recent years alcohol use and misuse have become a pressing cause for concern for countries worldwide, their governments and societies at large. Alcohol is now understood as not merely a contributor, but a causal factor in more than 200 disease and injury conditions, which equates to 5.1% of global disease and injury and 5.9% of all deaths. Furthermore, alcohol consumption is now the leading risk factor for death in men aged 15-59 (WHO Global Status Report, 2014, Mokdad et al. 2016).

The physiological impacts of alcohol consumption are far reaching and although the vast majority of research to date has been conducted in adults, these same health impacts may not be exclusive to the adult population. Young people are less likely to report extensive drinking histories and as such, the accumulative physiological effects of alcohol use are unlikely to present in the same ways that are observed in adults.

Nevertheless young people who consume alcohol are at increased risk of alcohol related health harms, which are likely to impact on their longer-term health. This unique developmental period in which a young person may be beginning to engage in such drinking behaviours carries known increased risks to health and as such, this period may present an opportune point in the prevention or limitation of physiological damage occurring in later adulthood.

1.1.1 Mental and Behavioural Disorders

The Global Burden of Disease Study (GBD, 2010) reported mental and substance use disorders as the 5th leading contributor of global burden, accounting for 183.9 million Disability Adjusted Life Years (DALYs), with the highest proportion occurring in those aged 10 – 29 years (Whiteford et al. 2013; Ferrari et al. 2014).

Alcohol use disorders account for 9.6% of the total burden of mental and substance use disorders with the largest proportion observed in 25-50 year olds followed by a gradual decline. Key risk factors for total burden of disease, which include alcohol use, increase significantly with age. Major risk factors contributing to burden of disease remain low in early adolescence although risk factors including alcohol use and unsafe sex are seen to rise sharply in early adulthood (Gore et al. 2011; Whiteford et al. 2013).

Population growth and ageing accounted for the vast majority of a 37% increase in global burden of disease between 1990 and 2010, nevertheless, burden attributable to alcohol use was associated with an increase in prevalence of these disorders and less so by the changing population levels and demographics (Degenhardt et al. 2013).

1.2 Consumption

1.2.1 Measurements

Alcohol consumption can be measured in several ways and often varies significantly across countries depending on their preferred method of data collection. Two more commonly used methods employ the alcohol per capita in litres of pure alcohol per person per day and grams of pure alcohol consumed per person per day.

1.2.2 Global Consumption

Global alcohol consumption reported by the WHO in 2010 revealed that individuals (aged 15 and over) consumed on average, 6.2 litres of pure alcohol per year. This in turn equated to 13.5 grams of pure alcohol per day.

Alcohol consumption varies significantly across countries with the highest levels being reported in the European and Americas regions and lowest levels in South-East Asia. Consumption levels were noted to be particularly low in the Eastern Mediterranean region. Interestingly, despite 14.7% of the world's population forming the WHO European Region, over a quarter of the world's alcohol consumption is accounted for by these member states (WHO, 2014).

1.2.3 Global Alcohol Consumption in Adolescents

Young people are more likely to experience the harms related to alcohol use from a given volume when compared to other age groups (Hilton, 1987; Midanik and Clark, 1995; Makela and Mustonen, 2000).

In 2010 the WHO reported that worldwide, young people (aged 15–19 years) consumed on average, 21.2 litres for males and 8.9 litres for females, of pure alcohol. Consistent with consumption levels observed in the adult population, adolescents total alcohol consumption per capita is observed to vary significantly across regions and as such, total consumption translates into an average of between 30-57 grams of pure alcohol per day for males, and 10-29 grams of pure alcohol for females (WHO, 2010). As previously reported in adults, regions noted to have the highest proportion of adolescent drinkers were found in the European and Americas while South East Asia and the Eastern Mediterranean regions reported the lowest (WHO, 2014).

Adolescents are likely to consume more than one type of alcoholic beverage (Fuller, 2013) and be more likely to experience the harms related to alcohol use from a given volume when compared to other age groups, which appears to remain the case when examining adolescents in Europe (Hilton, 1987; Midanik and Clark, 1995; Makela and Mustonen, 2000).

The European School Survey Project on Alcohol and Other Drugs (ESPAD 2011) revealed that in all but one European country included in the survey, 70% of students aged 15 to 16 reported having consumed alcohol at least once in their lifetime. Just over a half of students reported drinking alcohol in the previous 30 days.

The majority (75%) of countries reported approximately half of students consuming alcohol on or before the age of 13. The most common beverage type consumed for this age group was beer (44%) followed by wine (38%), cider (34%), alcopops (27%) and spirits (20%). The survey found that boys were more likely to report having tried alcohol by the age of 13 when compared to girls (Fuller et al. 2013).

The most commonly consumed beverage type in the previous 30 days was beer and was reported by 47% of students, this was followed by wine and spirits (37-38%), alcopops (32%) and cider (27%). A number of countries were highlighted for their particular preference for certain beverage types, this included more than 60% of German students reporting having consumed beer in the previous 30 days. Germany was also highlighted as having a high level of reported alcopops use. The report revealed 63% of students in Malta indicated having consumed wine in the previous 30 days in addition to the same proportion reporting spirit consumption for the same period. The report revealed beer and spirits to be the most likely beverage type to have been consumed on the last drinking occasion and that this accounted for around 70% of the total consumption (Fuller et al. 2013).

1.2.4 Unrecorded Levels of Consumption

Unrecorded alcohol consumption (produced or sold outside of normal government controls) accounts for almost a quarter (24.8%) of all alcohol consumption (WHO, 2010).

As seen with recorded consumption of alcohol, unrecorded consumption varies significantly across countries. In the South East Asia and East Mediterranean regions unrecorded consumption equates to more than 50% of total alcohol consumption. In addition to this, low-income countries have higher levels of homemade alcohol, while countries that ban alcohol mean up to 100% of alcohol consumption is classified as 'unrecorded' (WHO, 2014).

Unrecorded alcohol consumption is considered a sizeable factor when quantifying global alcohol use due to its impact on the global disease burden. Research has also highlighted associations between unrecorded alcohol consumption and increased heavy drinking occasions (Rehm et al. 2014).

1.3 Drinking Patterns

1.3.1 Abstinence

Despite reports of high prevalence of alcohol use throughout the world the majority (61.7%) of the world's adult population (15 years and older) were reported to have

abstained in the previous 12 months. Of this, 13.7% had previously drunk alcohol but reported having abstained in the previous 12 months (WHO, 2014).

1.3.2 Heavy Episodic Drinking

The World Health Organisation (WHO) defines Heavy Episodic Drinking (HED) as the consumption of 60 or more grams of pure alcohol on at least one occasion within a month. Among alcohol consumers worldwide, 16% reported having engaged in heavy episodic drinking (WHO, 2010).

Research indicates that the higher the Alcohol Per Capita Consumption (APC) the greater prevalence of HED. In addition, greater economic wealth of a country is associated with higher levels of alcohol consumption and fewer abstainers.

Young people (15-19 years) demonstrated the greatest prevalence of HED when compared to the rest of the population. Males were found to be 3 times more likely to engage in HED compared to females (WHO, 2010).

While the majority of students report having consumed alcohol in their lifetime, this does not translate to direct/indirect experiences of intoxication. The ESPAD (2011) survey highlighted considerable variation in intoxication reporting levels between countries and in some instances, gender. Denmark, Spain and the UK were highlighted as countries with higher reported levels of having ever been intoxicated on more than 10 occasions (21%, 18% and 15% respectively). Overall, on average approximately half of participants reported that they had been intoxicated on at least one occasion in their lifetime and 37% in the previous 12 months. In the majority of

countries, boys were more likely to report having been intoxicated however the reverse was noted for females in a number of countries including the UK and Ireland. Similarly, heavy episodic drinking (HED) whereby, a total of 5 or more standard drinks are consumed on one occasion was also more likely to be reported by males. A number of countries found that in fact, females were as, or in some instances more, likely to report having engaged in this higher risk drinking behaviour including, UK, Ireland and France. UK female participants were among the highest proportion (50% or above) to have reported engaging in this drinking behaviour (Fuller et al. 2013).

The ESPAD survey asked students to report the level of drunkenness experienced on the last day that they had consumed alcohol on a 10-point scale (1 'not drunk at all' – 10 'heavily intoxicated – not remembering what happened'). Boys reported higher average levels of intoxication (3.4) compared to girls (2.9), however in the UK the average score was found to be higher in female participants when compared to males. The average score was 3.1; the UK scored an average of 4.0, Ireland 3.8, France 3.4 and Germany 3.2 (Fuller et al. 2013).

1.3.3 Patterns of Drinking Score (PDS)

The Patterns of Drinking Score (PDS) is a composite measure, which aims to capture the way in which alcohol is consumed, in addition to the quantity. The aim is to reflect 'riskiness' of alcohol consumption and is associated with the burden of disease attributable to alcohol of a country.

Research highlights the impact drinking patterns can have on a nation's health outcome, even though they may share the same alcohol consumption levels. As such, drinking attributes are weighted according to the risk posed on a scale of 1 (least risky pattern of drinking) to 5 (most risky pattern of drinking). Those who report drinking with

meals or daily/nearly daily are deemed as having a lower level of risk (Rehm et al. 2013).

1.4 Beverage Preference

1.4.1 Global alcohol consumption: Beverage Type

The type of alcohol consumed by young people and adults worldwide is seen to vary geographically with both age and sex (WHO, 2014). Worldwide, spirits account for half (50.1%) of the populations (16 – 80 years old) alcohol consumption and is the most consumed beverage type in both the WHO South East Asia and Western Pacific regions. Beer features as the second most consumed alcohol type across the world (34.8%) and is the most consumed beverage type in the Americas regions, totalling over half (55.3%) of all consumption in these countries. Despite only 8% of worldwide-recorded alcohol consumption being in the form of wine, this equates to over a quarter of the total consumption in the WHO European Region (25.7%). While 'other' beverages (i.e. fortified wines, rice wine or other fermented beverages made of sorghum, millet or maize) which forms only 7.1% of total consumption worldwide, accounts for over half the total consumption (51.6%) in the African WHO region (WHO, 2014).

The WHO Global Strategy to reduce the harmful use of alcohol recommends 'member states endeavour to influence societies drinking patterns and harms through the implementation and enforcement of legislation for specific beverage types, according to the perceived level of advantage/disadvantage to society' (WHO, 2010).

Different types of alcoholic beverages have been restricted and/or favoured in different countries and cultures throughout history both by governments and its societies. From the temperance movements of the 18th century and the 'campaign against spirituous liquors' to the 'Alcopop tax' introduced in several countries including, Germany in 2004 and Australia in 2008, which sought to reduce the high level of alcohol consumption by young people and associated harms. Never the less, throughout the world and notably in the UK, the production, sale and consumption of alcohol is big business, with recent reports indicating that this industry has remained relatively unaffected during the more challenging economic times with continued growth and an expected UK market value of £45 billion by 2017 (IAS, 2014).

1.4.2 UK alcohol beverage type consumption: Adults

As seen throughout the rest of the world, the types of alcohol consumed by adults and young people in the UK can vary significantly with age and sex. In the UK during the previous week, the majority of men (62%) reported having consumed beer, lager or cider, while over a third (33%) had drunk wine and around a fifth had drunk spirits (22%). When examining adult females, their beverage preferences appeared somewhat different in that the majority (64%) had consumed wine, just over a third had drunk spirits (26%) and a fifth (19%) had drunk beer, lager, cider or shandy. Variations were also observed within different age groups, while the majority of men and a fifth of women reported consuming beer, lager, cider or shandy in the previous week these proportions were both seen to decline with age. In contrast, the consumption of wine in both men and women was seen to increase and level out for those aged between 55-74 years. Spirit consumption was observed to most likely occur in adults aged between 16 and 34 years and among men aged 75 years and older; while a mere 2% of men and women reported having drunk alcopops in the previous week and those that did were most likely to be aged between 16 and 24 years (HSCIC, 2014).

1.4.3 UK alcohol beverage type consumption: Young People

As seen worldwide, most alcohol consumed by young people in the UK is in the form of beer, lager or cider and research reports that these drinks are more likely to have been consumed in the previous week (72%) when compared to spirits (59%) alcopops (40%) and wine (38%). These proportions were also similar when examining levels of consumption with beer, lager and cider accounting for 5.5 units in the previous week and less than half of this total reported in the form of spirits (1.7 units) wine (1.7 units) and alcopops (1.3 units) (Fuller et al. 2015).

An individual's beverage choice will be influenced by a multitude of factors, be it the characteristics of the individual themselves, the influences from those around them and/or the complex interplay of beverage properties, doses and subsequent harmful effects. We know that young people are likely to be highly influenced by others drinking behaviours and peer effects are an important factor when examining beverage choice in this group (Borsari et al. 2001; Donovan et al. 2004; Martin et al. 2006; Bremner et al. 2011). Research consistently demonstrates that a young person is significantly more likely to drink alcohol if their peers do. Anderson et al. (2010) found that if a young person reported that all or most of their friends drank alcohol, the probability of having consumed beer in the past 30 days was found to be on average 68% higher for males and 80% for females. These effects were apparent for all beverage types including Alcopops, where males were 45% more likely to have consumed Alcopops and females 84%. These peer effects, although present were found to be lower for spirits and wine. This research suggests that females are more likely to be influenced by their peers than males.

There is also considerable interest mounting with regards to the monetary influence of alcohol beverage choice in young people. Throughout history governments have attempted to influence alcohol consumption through the restriction and/or favouring of

certain alcohol types. An example of this has been seen with the introduction of an 'Alcopop Tax' in a number of states, which is specifically aimed to reduce Alcopop consumption in young people. A report by the European Commission to provide an overview of the market for alcoholic beverages of particular appeal to minors (Anderson et al. 2010), remarked that when increasing taxes on certain beverage types, those typically deemed more appealing to young people i.e. Alcopops/pre-mixers are not 'unique' when compared to other beverage categories. The report suggested that there are no 'unique drivers' of such beverages pertaining to appeal to young people, which differed from those of other alcoholic beverages in general, and recommended that governments consider all alcoholic beverages when examining ways to reduce alcohol related harms in young people.

A common assumption is that young people are more likely to consume cheaper forms of alcohol, and this indeed may be true for some individuals, but research suggests that this may not be a clear indicator of preference. A US survey of 1,032 young people (13-20 years) found that although lower brand specific prices were associated with higher levels of consumption, young people indicated preferences for certain beverage types regardless of competing brand costs (Albers et al. 2015). If, as the research suggests alcohol appeals equally to some young people regardless of the drink type, exposure to advertisements and promotion of products may have a powerful role in influence of beverage choice in this group.

Despite the challenge of being able to demonstrate a cause-effect relationship between alcohol advertising and alcohol consumption in young people, both the UK Government and World Health Organisation highlight existing evidence that acknowledges the link between advertising exposure and alcohol consumption in those under the age of 18. Young people, who are exposed to alcohol marketing and advertisements, are more

likely to initiate drinking, or indeed consume more if already drinking (Snyder et al. 2006; Smith et al. 2007; Booth et al. 2008; Anderson et al. 2009; HM Government, 2012; WHO, 2014). Worryingly, a survey conducted by Alcohol Concern (2015) found that cheap and strong alcohol brands that are heavily advertised were more often reported as beverage types consumed by young people engaged in drug and alcohol services in the UK (Alcohol Concern, 2015).

A study examining beverage types consumed by young people (12-20 years old) in drug and alcohol treatment in England found a range of alcoholic beverage types were consumed. Previously described as the '*narrowing of drinking repertoire*' by Edward and Gross (1976) was similarly observed in young people engaged in treatment. They were reported to be more likely to consume the strong and cheap drink types, which afford the greatest amount of units with differences, related to gender and age (Alcohol Concern, 2015).

1.4.4 Beer

Beer is the most common beverage consumed by those aged 13 or younger in three-quarters of European countries (ESPAD, 2011), and the most likely beverage type to have been consumed in the last week by young people in the UK (72%) (Fuller et al. 2009). It is likely to be an attractive beverage type to young people who are seeking to get drunk with relative low costs (Edwards et al. 1994).

Research has suggested that the lower strength of the alcohol in beer and the larger quantities in which it is usually produced and consumed in, i.e. pints as opposed to shots of spirits, may allow a more gradual rise in blood alcohol concentrations in a young person. This suggests it may allow acute tolerance to develop over a longer period of time, which may or may not appeal to some young people (Smart et al. 1996).

Nonetheless, there are a large number of studies, predominately examining adults but with a growing number examining young people and beer consumption, which suggests that individual's who consume beer are more likely to consume larger volumes, with greater frequency, engage in binge type drinking behaviours and as such may, have an increased risk of developing an Alcohol Use Disorder when compared to other beverage types (Naimi et al. 1990; Smart et al. 1996; Jenson et al. 2002; Lintanen et al. 2003; Makela et al. 2011; Dey et al. 2013).

There are notable gender differences both in the consumption of beer and outcomes of harm, while UK girls are reported to have consumed fewer units of alcohol in the form of beer in the previous week when compared to boys (1.4 units compared to 7.1 units respectively), girls were observed to consume more beer than other beverage types. Smart and Colleagues (1996) found that women who included beer in their alcohol consumption were more likely to exhibit heavy and excessive drinking behaviours when compared to those who did not include beer in their alcohol intake.

Research has established the carcinogenic properties of alcohol that span all beverage types in varying degrees (Baan et al. 2007; COC, 2015). There is research, which suggests that beer may have greater associations with upper digestive tract malignancies when compared to other beverage types. One hypothesis is the higher concentrations of nitrosamines, a chemical compound that can be formed in the malting process and has been found to cause cancers in some laboratory animals are present in beer (Berger et al. 1998).

Beer has been a popular choice of alcohol type for young people for considerable time and remains an attractive option for young people today. The relative affordability of

beer when compared to other beverage types, in addition to the regular promotion of 'multi packs', are likely to prove a tempting offer to young consumers.

4.4.5 Cider

The UK has seen large increases in the production, sale and consumption of cider over the last decade. In 2014 UK manufacturers produced and sold £911 million of cider, up from £812 million in the year before. The industry believes the mounting popularity of alternative fruit ciders is likely to have boosted sales (ONS 2015).

Harms related to cider have often focused on high strength ciders, which are a popular choice for dependent drinkers, often associated with street drinkers due to its low cost and high strength content. In 2009 Heineken discontinued their 'White Lightning' product, a high strength cider which upon release was marketed as 8.4% ABV. This was subsequently reduced to 7.5%, following pressure from the government and mounting associations with negative societal impacts and was again reduced to 5.5% before being discontinued.

The concerns expressed with regards to high strength cider such as, low costs and high strength are equally likely to appeal to young people as a more affordable way to get drunk. Cider was found to be the beverage type most consumed by children younger than 15 years of age who were accessing treatment services in the UK (Alcohol Concern, 2015).

In addition to the low cost and high strength, value ciders are often produced in large quantities i.e. 1 litre bottles. which is often the cheapest way in which to purchase units of alcohol in this form. Bellis and Colleagues (2010) found that cider could be purchased for as little as £0.11 per unit, which equates to 5 units being comparable to

the price of a can of cola. This research also reported the consumption of multi litre cider to be associated with outdoor drinking, alcohol related regretted sex and violence when drunk (Bellis et al. 2010).

The rapid development of the fruit cider market lies in stark contrast against the associations of high strength 'street drinker' ciders, and are also likely to appeal to some younger people in a similar way in which Alcopops or flavoured mixers do, in so far as they can be more easily consumed due to the masking effects of fruit flavours and sweeteners. This, alongside the relative increased expense of alternative fruit ciders are likely to form two types of cider consumer in young people whereby, individuals with the intention or motivations to get intoxicated may choose to consume the cheaper, stronger cider types as a 'means to an end', where as the fruit cider drinker may wish to be able to consume alcohol in a social setting with a lower motivation for 'intoxication' or 'drunkenness'. The array of cider products is likely to create a wide range of interest from the varying type of young drinkers.

1.4.6 Alcopops

Alcopops have long been associated with young people. Launched in the 1990's concern quickly mounted with the introduction of these brightly coloured, highly sweetened flavoured alcoholic beverages, seemingly aimed to 'recruit' new drinkers and 'seduce' adolescents to drink heavily (Glenewinkel et al. 1998; Romanus, 2000) with the ethanol masking effects of sweeteners (McKeganey, 1998).

Young people at parties and social gatherings more often consume Alcopops, particularly when in the company of peers. Research has suggested that this is due to the 'positive and attractive' association of the Alcopop beverage (Hughes et al. 1999;

Leeming et al. 2002). Research has proposed that these young drinkers are likely to report social motives related to the consumption of alcohol and that these individuals may be at increased risk of consuming larger quantities at a higher frequency when compared to individuals who may have low social motives for drinking alcohol (Confederation Helvetica, 2003).

In a systematic review of the impact of Alcopops on adolescent drinking (2007) Metzner found that when compared to non-alcopop consumers, Alcopop drinkers were associated with an increased number of alcohol risk related behaviours including, risky and regretful sexual behaviours, physical conflicts, relationship difficulties with parents and a higher level of physical conflict. However, the review concluded that these Alcopop effects could not be supported beyond those of total quantity of consumed alcohol.

Kraus and Colleagues (2010) found that despite Alcopop consumers demonstrating an earlier onset of drunkenness this did not translate into any significant differences in the incidence of alcohol related risks, with the exception of an increased risk for engaging in unprotected and regretted sexual intercourse.

It appears that Alcopops are likely to appeal to young people who like to consume alcohol at social gatherings, parties etc, and who choose to consume Alcopops because of the visual appeal and ease of consumption compared to other alcoholic beverages, and tend to not drink to excess. The relative expense of alcopops, when compared to other beverage types may also impact both on how this beverage type is consumed and associated outcomes, as research indicates riskier drinking outcomes are more often associated with cheaper alcohol products (Bellis et al. 2001).

Alcopops have seen a steep decline in prevalence and popularity since 2004 and while overall consumption in young people has remained relatively stable, albeit with indications of a slight decline in overall consumption, beer and spirit consumption have been seen to increase during this same time period (Kraus, 2010).

A European Commission Review into the marketing and regulation of alcoholic beverages with particular appeal to minors suggested that these types of beverages, including Alcopops brought no added or unique health problems to young people when compared to other alcohol types (Anderson, 2010).

A previous study of 9,833 15-16 year olds in England found that Alcopop and wine drinkers were associated with a lower level of risk with regards to consumption and negative outcomes. Researchers went on to propose that young people's beverage consumption may in fact be a reflection of the individual's overall risk profile and that beverage preference is likely to form part of a larger complex risk profile of a young person's problem behaviours (Bellis et al. 2009).

Research suggests that Alcopops do not necessarily encourage young people to drink heavily (Glenewinkel et al. 1998; Romanus, 2000; McKeganey, 1998) but may in fact encourage young people to drink moderately due to sugary sweet contents which may prove more difficult to drink in large amounts, in addition to the higher price compared to other beverage types which contain the same amount of alcohol.

1.4.7 Wine

Wine is the second most consumed beverage type by young people in Europe (37%) with markedly high levels of consumption in Malta (63%) Czech Republic, Denmark and Greece (57%) (ESPAD, 2011). In the UK wine is the least likely beverage to have been consumed in the previous week by young people when compared to other beverage types (38%) although, girls were noted to have consumed more when compared to boys (48% and 28% respectively) (Fuller et al. 2009).

A number of research studies have sought to highlight the health benefits of wine drinking in adults. A meta-analysis of 26 studies found an average reduction of 32% of overall vascular risk associated with wine consumption (Siegel, 2011). Earlier research highlights that any conceivable health benefits or protective factors of wine drinking varies considerably when controlling for age and gender and that any apparent superior health benefits that wine drinkers may demonstrate are likely to be a reflection of the overall better health of the individuals who prefer wine to other beverages, as opposed to any characteristics of wine itself (Rimm et al. 1996). This notion has been echoed in a number of research studies which report wine drinkers to have better social backgrounds and lower levels of smoking and overall alcohol consumption (Klatsky et al. 1990; Gronbaek et al. 1999; Barefoot et al. 2002; Martensen et al. 2001).

Wine has often been regarded as a social habit, associated with drinking in moderation i.e. accompanying meals in the presence of others (Alvarez and Del Rio, 1994; Smart, 1996; Smart and Walsh, 1995). Research has reported wine drinkers are at a decreased risk of becoming heavy drinkers when compared to other beverage types and adolescents who prefer wine have been observed to drink more moderately when compared to other young drinkers (Jensen et al. 2002; Gronbaek et al. 2004; Kuntsche, 2004; Siegel, 2011). In addition to moderation, wine drinkers are also noted to have a

later onset of drunkenness when compared to non-wine consumers (Kraus et al., 2009).

Research into the health costs and/or benefits of wine has predominately been examined using an adult population. The drinking career of a young person is unlikely to be of sufficient length to enable any health benefits or costs to be measured objectively. Nonetheless, it will be important to consider these factors when disseminating health information to young people on the use of alcohol including the consumption of wine.

1.4.8 Spirits

Distilled spirit strength is more variable than other beverage types and often viewed as more burdensome, with associated rapid increases in blood alcohol concentrations (BACS) and subsequent impairments, even when compared to the same quantity of other beverages (Smart, 2006; Room et al. 2011).

Research has indicated that spirits are more likely to be implicated in alcohol poisonings when compared to other beverage types. A number of studies have found alcohol poisonings to correlate more closely with sales of spirits when compared to total alcohol sales (Makela et al. 2007). All alcohol is associated with increased risk of mortality although Spirit consumers may be at further risk. Sales of spirits have been found to be implicated in a number mortality outcomes including, fatal traffic accidents, homicide and suicide (Kerr and Ye, 2011; Makela et al. 2011).

Research has demonstrated spirit consumption to have stronger associations with aggressive and uncontrolled behavioural reactions which are likely, in turn, to put the

individual at a greater risk of injury (Takala et al. 1957; Boyatzis 1974; Pihl et al. 1984; Murdoch and Phil 1988). Kerr and Ye (2011) similarly, found that spirit consumption was likely to feature where there is a strong cultural association of alcohol and violence.

Makela (2011) noted that *'the easiest way to consume large quantities of alcohol, to carry it around and to drink it unnoticed is to consume it in the form of spirits. Spirits provide a faster more effective and dependable way of getting drunk'*. Edward (1994) had previously highlighted that spirits may hold particular appeal to some young alcohol consumers who want to get drunk and who are on a small budget.

A US youth survey found spirits to be disproportionately popular among 12-18 year olds identified as binge drinkers and almost twice as popular as the next most popular beverage. These drinkers were also associated with a variety of health risks including, drinking and driving and engaging in unprotected sex (Siegel et al. 2011). Recent research in the UK highlighted that young people accessing drug and alcohol treatment services were more commonly consuming spirits. Vodka was noted to be particularly popular with young people for a number of reasons including, low cost, strength and its colourless appearance which makes it easier to mix with other beverages (Alcohol Concern, 2015).

The examination of preference and differences between beverage types and alcohol related harms continue to be explored. Disparate findings further highlight this research gap, particularly for young drinkers. Much of what is known with regards to different beverage types and the impact have been derived from adult populations. Differences between adults and young people's alcohol use can mean that findings may not translate to young people's alcohol preferences and drinking behaviours.

1.4 Trends and Projections

Consumption levels are predicted to continue to increase in over half of the WHO regions in the next 10 years. It is anticipated that the WHO European Region will demonstrate a continued decrease in consumption as evidenced in recent years, but the region will continue to be the WHO Region with the highest per capita consumption globally.

Between 2005 and 2011 the percentage of young people aged between 16 and 24 who reported having consumed alcohol in the previous week has remained consistently below the UK average (Fuller et al. 2012).

The Office of National Statistics (ONS) reported in 2001 that average consumption among 16 to 24 year olds had peaked at 19.4 units per week (7.3 units above the overall average of 12.1 units). In 2010 they reported an average of 11.1 units, which was the first time levels of consumption among young people were below the overall average. This suggests reductions in both the consumption and hazardous use of alcohol in this period.

While recent trends suggest that there may be fewer young people reporting that they have consumed alcohol, those that do, appear to be consuming larger amounts when they do engage in drinking behaviours, and are doing so more often (DoH, 2007).

1.5 Pre-Clinical Studies of Alcohol and Neuropsychological Functioning

1.5.1 Animal Studies

Ethanol administration in adolescent rats is associated with detrimental effects on some aspects of neuropsychological functioning, and a variety of structural brain abnormalities (Brown, 2004; Crews et al. 2006; Pascual, 2007).

Although seemingly less vulnerable to some of the effects of ethanol including, the sedative effects (Silveri and Spear, 1998) and displaying a faster recovery time in some motor tasks when compared to adult rats (Little et al. 1996; White et al. 2002) adolescents were also observed to develop rapid acute and chronic tolerance (Swartzwelder et al. 1998). While these differences may be considered somewhat beneficial to the young individual, those same effects may enable adolescents to drink large quantities of alcohol with little awareness of the effects it may be having on their neurodevelopment and function (Guerri et al. 2010).

Studies have also revealed less advantageous differences between adolescent and adult rats including, damaged frontal cortical regions and learning and memory impairments which have been seen to continue into adulthood (Crews et al. 2000; White et al. 2000; Crews et al. 2001). Studies have shown that ethanol administration in adolescent rats not only inhibits long-term potentiation (Swartzwelder et al. 1995; Li et al. 2002) and synaptic plasticity (Guerri et al. 2010) in the hippocampal region, but has also been seen to increase neuronal death in younger rats, both within the hippocampus and prefrontal cortex (Pascual et al. 2007). This can lead to disruptions in

memory and memory related functions to a greater degree in adolescent animals when compared to adults, resulting in lasting behavioural and cognitive consequences.

Animal studies have advanced our understanding of both the biological and pathophysiology impacts of alcohol use and continue to be used to explore the biological mechanisms, which may mediate alcohol-using behaviours in adolescents. Furthermore, unlike clinical studies, animal models can control for variables more easily in the examination of alcohol dose-response relationships in the biochemical and physiological systems. Animal studies have brought about significant advancements in our understanding of the role of intermittent alcohol use and subsequent withdrawal have on the brain structure. Understanding these mechanisms of harm will be paramount when developing interventions and hypotheses in future research (Tabakoff, 2000).

Animal studies allow researchers to examine the impact of alcohol in ways which may be deemed unethical in humans however, this brings with it limitations with regards to both the validity and generalisability to humans. While results generalised from animal models to humans tend to focus their attention on the more common biologic processes and disease mechanisms, they are unable to account for the impact of any suffering through rough handling, fear, confinement and presence of other animals or humans, on the biological and psychological reactions that may effect behaviour (Kukull, 2012; Shapiro, 1998). Animal studies bear little, if any similarity to the contextual complexity in which humans experience alcohol in day-to-day life. As a result many researchers question what conclusions can be drawn from such studies. Not only are animal studies unable to account fully for the variation in absorption, distribution and biotransformation, no animal is able to reproduce or indeed capture the human phenomena of alcohol use and its effects (Shapiro, 1998).

Nevertheless, there has been a notable rise in animal studies in recent years, which have contributed to the expanding literature examining the effects of alcohol misuse, although

questions remain of how best to translate this to human studies. There remains a paucity of studies exploring the effects of heavy alcohol use on the development and neuropsychological functioning of adolescents (Squeglia et al. 2009).

1.6 Neurodevelopment

The process of adolescence is not synonymous with puberty and established research, which includes longitudinal MRI studies, have demonstrated that neuronal proliferation and development is not complete until approximately 25 years of age (Geidd, 1999; Baird, 1999; Gavin, 2007; Sylwester, 2007). This presents a critical period of development whereby, the initiation and continuing use of alcohol may have detrimental consequences for vulnerable adolescent brain structures and neurocognitive functioning.

The limbic region undergoes significant changes during adolescence, while the prefrontal cortex continues to undergo maturational changes into the third decade. It is these developmental features of the adolescent brain which researchers have proposed account for many of the observed phenomena in adolescence (Somerville et al. 2010; Giedd et al. 2015). Two processes take place during this time; 'synaptic pruning' whereby the brain develops new synapses (synaptic proliferation), which results in quantities vastly exceeding that of an adult, before undergoing a period of 'pruning' where well-established connections and pathways are strengthened, and infrequently used pathways are eliminated. It is believed that this process enables functional networks to be finely tuned to enhance circuitry efficiency (Blakemore and Choudry, 2006).

The second process of interest is 'myelination', the development of material made up of protein and fatty substances, which forms a sheath around axons and enables impulses to be transmitted efficiently. When this substance is damaged, the impulses slow down. As myelin appears white in neuroimaging, studies have been used to confirm steady increases in white matter in the frontal and parietal cortex during adolescence when compared to younger children (Sowell et al. 1999). It is these processes within the prefrontal cortex, which appear to have a different time course than other brain regions. While this brain plasticity can be advantageous in the development of neurological efficiency, it can also mean that adolescence presents a time of structural and developmental vulnerability and could leave individuals particularly vulnerable to the effects of alcohol (Windle, 2008).

Heavy drinking in young people is indeed problematic and highly prevalent (Department of Health, 2009; Johnston et al. 2009; Archie et al. 2012), while early onset of alcohol use has been associated with longer-term alcohol related problems (WHO, 2012). Research has yet to determine early neurobiological markers associated with neuropsychological development in young alcohol users.

1.7 The impact of alcohol neuropsychological functioning: A Systematic Review

1.7.1 Objective

Research examining brain development in adolescents who drink alcohol is still very much in its infancy with many unanswered questions remaining. Heavy drinking in adolescence could impair brain structure and cognitive function, which in turn could have detrimental impacts in later life. This study undertook a systematic review of current literature examining the impact of alcohol on neuropsychological functioning in adolescents.

1.7.2 Introduction

The relationship between chronic alcohol use and cognitive impairments in adults is now well established, with consistent findings in visuo-spatial, executive functioning, attention and working memory (Yucel et al. 2007; Harper. 2009). Research examining brain development in adolescent alcohol users appears to support the hypothesis that patterns of impairments draw some similarities to those found in adults. However, it remains unclear what the impact the age of onset and quantities consumed in this population have in relation to neuropsychological outcome.

The advancement of neuroimaging techniques has enabled researchers to demonstrate the functional and structural changes excessive alcohol use can have on the human brain, at a time when the young person may be making decisions around their future course of educational, social and occupational pathways. However, early neurobiological markers associated with neuropsychological development in young alcohol users have yet to be determined.

The DSM-V defines 6 key domains of cognitive function, executive function, complex attention, perceptual-motor function, learning and memory, language and social cognition, each of which have its own sub domains. While research continues to advance our understanding of the brain structures and associated neurocognitive functions, it remains difficult to achieve consensus on the exact number, definition and function of domains (Miyake and Friedman, 2012).

For the purpose of this review and drawing from research described in this chapter cognitive domains of interest were identified to include; executive function, attention/inhibition, visuo spatial, memory, affective and impulsivity and decision/risk taking.

The literature search identified 7 literature reviews, which examined alcohol related brain damage/cognitive deficits in adolescents. Several of the reviews note that while researchers have begun to identify some differences in neuropsychological function in adolescents who use alcohol, our understanding of this unique developmental period remains limited.

Blakemore and Choudry's (2006) narrative review of histological and brain-imaging studies highlighted the rapidly evolving field of study into the implications for executive function and social cognition in adolescents. They also note that this developmental period might be more sensitive to 'experimental input', particularly when examining aspects of executive function and social cognition. While this review does not focus on the impact of alcohol on these cognitive functions, it highlighted how behaviours

commonly associated with adolescence including, attention and impulsivity, may reflect brain and cognitive changes during this developmentally sensitive period.

Similarly a later narrative review by Windle and colleagues (2008) highlighted between ages 10-15 to be a notable period for transitions, and in particular, a period whereby both the initiation and consumption of alcohol escalate. It also highlights significant changes both in adolescent family, peer and romantic relationships and exposure to new societal and cultural influences. While the focus of the review is not on the neurological impact of alcohol, it emphasises adolescence as a period of significant growth in cognitive processes. The study also reports an increase in the rates of many psychopathologies including substance misuse during this time (Angold et al. 1998; Costello et al. 2002).

A further narrative review by Squeglia and colleagues (2009) examined neurocognition, brain structure and brain function in adolescent alcohol users, in the context of brain maturational processes. The narrative review reported subtle but notable deleterious effects on neurocognitive function in adolescents. Studies revealed decrements in memory, attention, information processing and executive function. The authors suggested that these decrements might emerge as a consequence of volumetric reductions in important brain structures including, the hippocampus, compromised quality of white matter and abnormalities in neuronal activation patterns in cognitive tasks.

Deas et al. (2000) provided a summary of research from the Research Society on Alcoholism Symposium 'Adolescents Are Not Adults: Developmental Considerations in Adolescent Alcohol Use' and highlighted the under representation of adolescents in the development of professional nosologies of substance use disorders. The report highlighted research from Langenbucher et al (1997), which examined between-group

differences including onset patterns and symptom prevalence. They concluded that adolescent dependence may be best described by symptoms of withdrawal and tolerance, in addition to impaired control, and suggested future research should build an understanding of psychological problems that adolescents experience as a result of alcohol use.

Similarly, Welch (2013) systematic review of 12 imaging studies, which examined brain structural differences associated with alcohol abuse and dependence in adolescence, suggested that adolescent alcohol users who fall short of the formal diagnostic criteria for AUD may be associated with brain structural abnormality. The review found that while it may be assumed that young adults are more likely to have consumed more alcohol over a longer period of time when compared to adolescents, and may be reflected in a direct exposure-response effect when examining brain structure and function, the opposite was in fact found. Effects including hippocampal and prefrontal volume reduction among adolescent alcohol user groups were found to be greater when compared to young adult groups. The review supports earlier studies, which suggest that alcohol may be interacting with adolescent specific maturational processes.

A systematic review by Ewing and colleagues (2014), examined 21 studies that investigated brain activity using fMRI in adolescent alcohol users (AU) and non alcohol users (non-AU) while undertaking tasks including; verbal/spatial working memory, paired associates and a gambling paradigm. Results found no group difference in task performance. However, the review did highlight notable different patterns of brain response across tasks examined. The review found AU engaged fewer task relevant brain regions and utilised numerous task irrelevant regions. Consistent with earlier reviews (Squeglia, 2009; Welch, 2013) Ewing (2014) noted lower brain volumes in several prefrontal areas, less working memory integrity and lower levels of brain activity

(BOLD response) for AU and non-AU groups, which are understood to be critically involved in executive control and function. It was also highlighted that female adolescent alcohol users may have an increased vulnerability for alterations in both the brain structure and function.

All of the reviews highlighted the cross sectional nature of the majority of studies, which has implications for establishing any causal influences of alcohol on adolescent neurological structures and cognitive functioning. Both Welch (2013) and Ewing (2014) note variability in study methods including, recruitment, inclusion criteria and image processing and interpretation. Furthermore, both of the systematic reviews (Welch, 2013 and Ewing, 2014) note small samples (n24-128), which may have implications for subsequent analyses.

A number of the reviews highlight comorbidity to be a particular problem in studies of adolescents who use alcohol, which may confound observed abnormalities and deficits (Windle, 2008; Welch, 2013; Ewing, 2014). Windle (2008) also noted that by stringently controlling for confounders including; other substance use, mental health, head injury and family history, that this may limit the generalisability of results. The review also noted important considerations when measuring abstinence, and potential impacts of this requirement on self report and engagement in this population.

While examining the early stages of alcohol initiation any neuropsychological impacts that may occur are likely to do so over a period of time. Any difference in effect may present as 'subtle', but may translate to significant deleterious effects on adolescent development and function.

The reviews highlight continuing disparity in results, and the need to continue to conduct research with adolescents who use alcohol in order to empirically evaluate the

impact of drinking behaviours on the developing brain. Questions remain as to whether alcohol use during adolescence causes cognitive impairment and change in neurodevelopment. There is also a need for further understanding of critical periods or factors, which may increase vulnerability to such effects.

Research to date points to a continuing paucity of research examining the impact of alcohol on the neurological development and functioning in adolescents. Research aimed at developing our understanding within this area will be fundamental when developing hypotheses and future interventions for this population group. As such, this study undertook a systematic review of current literature which focused on the impact of alcohol on neuropsychological functioning including executive function, attention/inhibition, visuo-spatial, memory, affective/impulsivity and decision/risk taking, in adolescents aged between 10 and 17.

1.7.3 Methods

A search in computerised databases (Embase, Medline and PsychInfo) was conducted using the following keywords: 'adolescents' OR 'teenagers' OR 'young people' AND 'neuropsychological functioning' OR 'neurocognition' OR 'cognitive' OR 'neurodevelopment' AND 'alcohol'. Articles included were published prior to 30th April 2016. In addition to the databases, bibliography searches of full texts to assess for eligibility were undertaken to identify further relevant papers.

Duplicates were removed and study titles and abstracts were reviewed to identify those deemed relevant for further data extraction. Where abstracts were unavailable or insufficient, full article reviews were conducted to determine relevance.

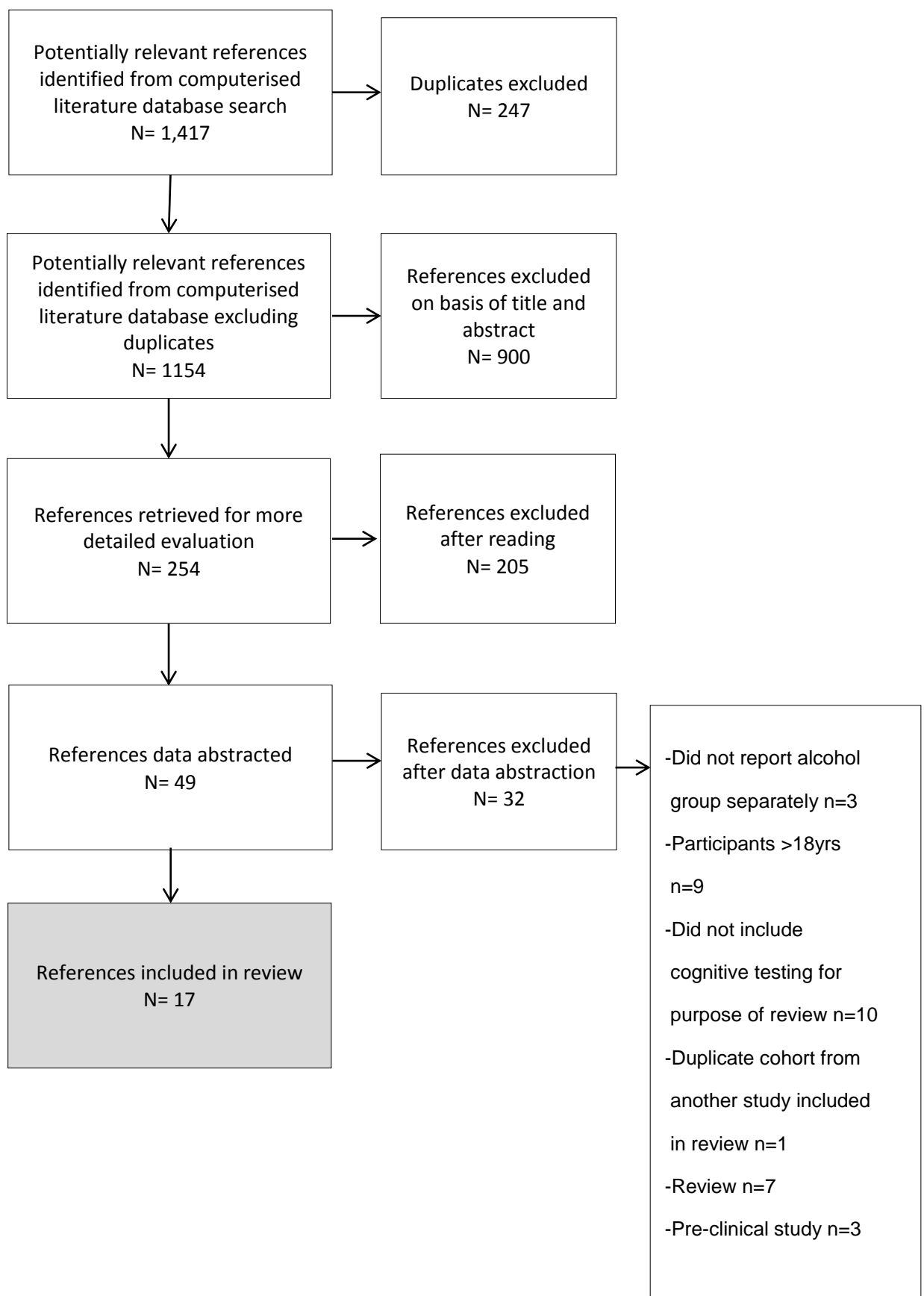


Figure 1: Search strategy used to screen and identify relevant reports

1.7.4 Participants

Participants included were 1) male or female 2) between 10 and 17 years 3) either abstinent or deemed 'non-hazardous' alcohol users or identified as hazardous alcohol users (determined using validated consumption and/or diagnostic measures i.e. AUDIT, DSM). For the purpose of this review, general and clinical populations were both considered in the systematic searches and subsequent reviews of studies for inclusion.

Exclusion criteria were 1) psychiatric diagnoses other than substance misuse/alcohol use disorder 2) primary psychoactive substance use other than alcohol, those with secondary substance use were considered for the purpose of the review subject to other criteria 3) head injury history involving loss of consciousness >2 minutes or serious medical conditions that could compromise neuropsychological performance.

For the purpose of this review both general and clinical populations were included, in addition to this both cross sectional and longitudinal studies were also considered in the systematic searches and subsequent reviews of studies for inclusion (Appendix 2).

1.7.5 Results

1.7.5.1 Executive Function

Over half (8/17) of the studies included in this review examined aspects of executive function and found impairments within the alcohol using groups (Moss et al. 1994; Giancola et al. 1997; Brown et al. 2000; Squeglia et al. 2009; Hanson et al. 2011; Thoma et al. 2011; Winward et al. 2014; Gil-Harmandez et al. 2016).

Damage to this cognitive function can result in increased impulsivity, difficulty in abstract thinking and an impaired ability to plan. This function can be measured with various paradigms and the following were included in studies as part of this review; WISC-R similarities, arithmetic and vocabulary tasks were used in 6 studies (Moss et al. 1994, Tapert et al. 1998, Hanson et al. 2011, Squeglia et al. 2009, Medina et al. 2007, Giancola et al. 1997) all of which reported varying degrees of impairment in alcohol using adolescents performing these types of tasks, albeit with differing impacts and outcomes within the groups.

In contrast to these reported differences a number of studies have found no differences in alcohol users and in some cases have reported greater levels of executive functioning with observed gender effects. Both Giancola et al. (1997), Winward et al. 2014 and Gil-Hernandez et al. (2016) reported differences attributable to the pattern of alcohol intake in a number of executive functioning tasks including the Stroop Colour Task and Block Design, which examine planning, organisation, and sequencing when compared to healthy controls. Further to these results, Winward et al. (2014) examined rates of recovery in Heavy Episodic Drinking (HED) adolescents (16-18 years) and found that while this group demonstrated some improvement in executive functioning over a 4-week period of abstinence, this was 11% lower than that of the control group.

While these studies did not find any significant effect of gender, other studies have. Moss et al. (1994) found adolescent male alcohol abusers demonstrated less perseveration errors on the Wisconsin Card Sorting Task compared to male controls. Authors suggested that this could indicate female alcohol abusers sustain different impairments in this frontal lobe function compared to males. The remaining 4 studies

(Brown et al. 2000, Squeglia et al. 2009, Hanson et al. 2011 and Thoma et al. 2011) did not find gender differences in tests of executive function.

Thoma et al. (2011) found that the intensity (more drinks per drinking day) of drinking was associated with reduced executive function in both male and female adolescents whereas, frequency of drinking was not found to have any significant relationship with neuropsychological outcome. Thoma et al. (2011) proposed two possible rationales for this difference, that adolescents with a pre-existing lower executive function are more likely to drink with greater intensity and/or higher quantity of drinks per occasion impairs executive functioning.

1.7.5.2 Attention/Inhibition

A total of 6 studies assessed these constructs using a range of neuropsychological measures (Tarter et al. 1995; Peeters et al. 2012; Squeglia et al. 2009; Tapert et al. 1998; Winward et al. 2014; Hanson et al. 2011). Tarter et al. (1995) found PSUD adolescents demonstrated lower sustained attention in the Stroop Colour Word Task. This was supported in a later study by Peeters et al. (2012), who found lower response inhibition performing the same task in at risk (of developing AUD) adolescents.

A total of 4 of the 6 studies used the WISC-R/WAIS-R digits forwards/backwards tasks. Squeglia et al. (2009) found worsening in sustained attention related to greater hangover symptoms in the year before follow up in boys. In contrast both Tapert et al. (1998) and Winward et al. (2014) found withdrawal symptomatology did not account for significant variance in attention. However, Tapert went on to report that while attention levels did not differ on baseline (15.9 years) those that steadily abused alcohol or other

drugs over a 4 year period did demonstrate moderate but significant deficits in attention by late adolescence.

In contrast to all of these studies Hanson et al. (2011) who also used a series of tests including WISC-R/WAIS-R digit tasks, in a small sample (n=51) did not find any decrements in attention.

In addition to these results, Moss et al. (1994) found significantly lower verbal and full scale IQ scores in alcohol abusing adolescents with an overall trend towards lower age standardised scores in reading ability and spelling. Tarter et al. (1995) found female substance abusers scored significantly lower in the domains of attention, intellectual capacity, language competence and academic achievement, although no relationship was found between the severity of substance use and level of cognitive deficit.

1.7.5.3 Visuospatial

A total of 8 studies examined visuo-spatial functioning within this review, of which 4 used the block design task (Tapert et al. 1998; Brown, 2000; Squeglia et al. 2009; Hanson et al. 2011; Winward et al. 2014; Winward et al. 2014; Nguyen-Louie et al. 2015). All studies with the exception of Winward et al. (2014) reported reduced visuo-spatial function in alcohol groups compared to controls. Tapert et al. (1998) suggested severity of withdrawal may be particularly pertinent to the neuropsychological functioning in adolescents and any withdrawal experiences in the 3 months preceding assessment were associated with poorer visual spatial performances. Building on this research both Brown et al. (2000) and Winward et al. (2014) found visual motor integration and visuo-perception were more akin to withdrawal histories. Over a 4 week monitored abstinence period, Winward et al. (2014) reported that HED

adolescents did demonstrate some observable improvement on the block construction tasks. However, complex figure reproduction tasks revealed consistently poorer outcomes across time in this group, suggesting deficits continue to impact on individuals with previous alcohol misuse even after periods of abstinence.

In a 4 year follow up study including, digit span backwards and Corsi block tapping tasks, Khurana et al. (2013) reported increases in drinking frequency did not impact on the developmental trajectories of working memory – of which visuo-spatial memory is a component, but that those participant's with pre-existing weakness in working memory demonstrated increases in drinking.

In a regression analysis Squeglia et al. (2009) found that more drinking days for females in the year prior to follow up predicted greater decline in performance. Similarly, Hanson et al. (2011) did not find any differences in function at intake but did find greater cumulative alcohol use predicted poorer visuospatial construction at 10 year follow up.

Contrary to all these studies, no effect of substance use and visuospatial functioning was found in Thoma et al. (2011) study.

1.7.5.4 Memory

A total of 9 studies assessed memory, using components of the California Verbal Memory Test (CVLT) - a well-established neuropsychological test of verbal memory. All 9 studies found impairments in a range of tasks in alcohol using groups.

In addition, Medina et al. (2007) examined hippocampal volume and asymmetry in adolescent alcohol users and found this group demonstrated more right>left asymmetry than controls. Interestingly, this study found increased asymmetry in the control group was associated with improved verbal learning. However, the alcohol group demonstrated a significantly different pattern of hippocampal asymmetry to be associated with reduced verbal learning performance. Authors suggested that smaller left hippocampal volumes and greater right>left asymmetry could indicate a degree of impaired neuronal processes, the functional outcome of this being impaired verbal learning.

Brown et al. (2000) reported new learning was not associated with alcohol use but found significant differences in delayed recall and retention tasks, with more lifetime withdrawal experiences associated with reduced performance on delay trials. Similarly, a later study Nguyen-Louie et al. (2015) reported that both greater quantities and frequency of alcohol use predicted poorer verbal memory functioning at a 4 year follow up. Drinking days in the past year predicted poorer scores on long delay free recall tasks, while HED was found to predict worse scores in short delay free recall. These results supported an earlier study by Winward et al. (2014) who also reported poorer performance in HED adolescents on both short and long delay cued recall of verbal memory with scores not seen to improve over a period of 4 weeks monitored abstinence. Furthermore, despite these reported differences between the HED and control group in tests of verbal memory, these did not differ significantly across time. Of particular interest in this study was the finding that differences observed in verbal recall were noted in users of both alcohol and marijuana, but not found in those whose substance of choice was predominately marijuana. The authors eluded to the

possibility that heavy alcohol use may have particular relevance for these areas of cognitive weakness.

Somewhat surprisingly, Moss et al. (1994) found alcohol users made significantly fewer perseverative errors in both free and cued recall tasks and performed better on the delayed recognition test which was consistent with previous research by Tapert et al. (1998) but found withdrawal symptomology did not account for any significant variance in memory. Correspondingly, Hanson et al. (2011) found that withdrawal experiences were not predictive of performance in a 10 year follow up but found greater cumulative alcohol use predicted reduced verbal learning and memory.

1.7.5.5 Affective and Impulsivity

A total of 5 studies considered affective and impulsivity functions in adolescent alcohol users and a range of neuropsychological tests were used for this purpose. Giancola et al. (1997) highlighted the role of executive function in self-regulating behaviours, and in a later study found Psychoactive Substance Use Disorder (PSUD) groups scored significantly lower in impulsivity performance tasks (Giancola et al. 1997). Khurana et al. (2012) provided longitudinal evidence in support of this, suggesting that pre-existing vulnerabilities in working memory and increased alcohol use were associated with reduced self-regulatory performance outcomes.

Building on this earlier research Nees et al. (2012) observed higher behavioural impulsivity in this cohort and went on to evidence heightened traits of novelty seeking and impulsivity in alcohol using participants using a monetary incentive delay task.

Findings were further supported in a recent study by Gil-Hernandez and Garcia-Moreno (2016) who found reduced inhibitory control and heightened impulsivity in a cohort of both moderate and binge drinking adolescents (12-18 years). They similarly concluded that adolescents who present as being more impulsive may be more likely to engage in behaviours which could provoke negative consequences, including substance misuse.

1.7.5.6 Decision/Risk Taking

Two studies considered decision and risk taking functions in adolescent's that use alcohol. Nees et al. (2012) study aimed to identify the contribution of reward related brain responses and found a contribution of personality traits including, impulsivity and behaviour involving risk taking, adjustment and delay aversion in the characterisation of early onset drinking in a general population sample. Gil-Hernandez et al. (2016) highlighted that care should be taken when examining decision and risk taking behaviours in adolescents and in those that consume alcohol, as these are currently not well defined. This in turn makes them difficult concepts to understand and measure in a population, which is susceptible to such behaviours at a period of complex developmental transition.

1.7.6 Conclusions

Despite the use of different outcome measures and disparate findings, a number of studies have highlighted associations between cognitive impairments in heavy drinking adolescents, not found in non-drinking adolescents in tasks which involve, visuo-spatial functioning (Tapert et al. 1998; Brown et al. 2000; Squeglia et al. 2009; Hanson et al. 2011; Tarter et al. 1995; Mahmood, 2009; Winward et al. 2014; 2014; Ngugen-Louie et al. 2015) attention (Tarter et al. 1995; Tapert et al. 1998; Squeglia et al. 2009; Hanson et al. 2011; Peeters et al. 2012; Winward et al. 2014) Impulsivity (Giancola et al. 1995; Khurana et al. 2012; Nees et al. 2012; Gil-Hernandez and Garcia-Moreno, 2016)

memory (Moss et al. 1994; Tarter et al. 1995; Tapert et al. 1998; Brown et al. 2000; Medina et al. 2007; Mahmood et al. 2009; Squeglia et al. 2009; Hanson et al. 2011; Winward et al. 2014) executive functioning (Moss et al. 1994; Giancola et al. 1997; Brown et al. 2000; Squeglia, 2009; Hanson et al. 2011; Thoma et al. 2011; Winward et al. 2014; Hanson et al. 2011) and decision making (Nees et al. 2012; Gil-Hernandez and Garcia-Moreno, 2016).

In an attempt to draw distinctions between the causes and consequences of alcohol use, studies have begun to prospectively examine the relationship between alcohol use and neuropsychological functioning (Tapert et al. 2002, Squeglia et al. 2009; Hanson et al. 2011; Khurana et al. 2012). In addition, recent studies have begun to examine pre-morbid cognitive function weaknesses, which may produce or exacerbate neurological vulnerabilities in adolescent's alcohol using behaviours.

However, a limitation in the majority (13/17) of these studies was the lack of lifetime abstinent adolescents as a control group. With unclear dose-response relationships, few lifetime abstinent control groups, and relatively low levels of alcohol consumption evidently needed to impact on neuropsychological functioning, results may begin to shed some light but as highlighted in a recent review, literature to date mainly highlights 'indicators for' as opposed to cause-effect relationships (Peeters et al. 2014). Similarly, as noted by several of the authors included in this review, is that while we may be able to identify some differences in neuropsychological function in adolescent's who consume alcohol, there remains a large gap in understanding of this complex neurological developmental period. Equally, as a young person may be in the early stages of exploring and initiating alcohol use, any impacts from this substance are unlikely to have established themselves in order to be able to manifest in differences.

The small number of studies has also led to limitations in the application of a meta-analysis for the purpose of this review. Neuropsychological measures and their outcomes were examined to determine suitability of a meta-analysis and it was felt that at present this analysis would not be appropriate (see Appendix 3).

Furthermore, research examining neuropsychological development in adolescent's who drink alcohol is still very much in its infancy with findings often hampered by small samples (samples included in this review ranged from 37-358), with further confounding factors including, poly-substance use, psychiatric co-morbidity and unclear dose-response relationships, all likely to contribute to the disparate findings observed. Identifying underlying factors linked to the emergence and progression of alcohol use supports an increased lifespan perspective on drinking patterns.

1.8 Potential Mechanisms of Harm

Mechanisms underlying ethanol-induced brain damage are not well understood, although animal studies have proposed two possible processes; Animal studies have consistently demonstrated the neurotoxic effects of ethanol with direct effects on microglial cell development and function. This has provided further evidence of an increased vulnerability on the adolescent brain structure and detrimental impacts on cognitions including, learning and memory dysfunctions when compared to adults (Markweise et al. 1998; White and Schwartz, 2005).

Mounting literature and preclinical studies have also indicated a direct effect of ethanol on cell function and as a result, neuro-inflammation. Findings have suggested that this increase in brain inflammatory mediators could play a key role in both neuro-behavioural deficits and ethanol-induced brain damage in adolescent animals (Pascual 2007; Guerri and Pascual, 2010). Studies have shown that a single dose of ethanol during adolescence to have detrimental impacts on proliferation and neural survival in animals (Crews et al. 2006). Results suggest that episodic drinking in adolescence may have long-term impacts on neurogenesis.

Intermittent ethanol use and subsequent withdrawal has also demonstrated marked increases in synaptic activation of NMDA receptors (Hendricson et al. 2007), which may give rise to the second process which researchers have suggested may underlie ethanol-induced brain damage – excitotoxic neuronal damage (Predergast et al. 2004; Self et al. 2005). Animal studies have shown greater levels of neuronal damage in the frontal anterior and cortical regions in young rats that have been exposed to heavy ethanol consumption, when compared to adults (Crews et al. 2000). Neuronal damage in young animals following exposure to intermittent ethanol administration has revealed lasting cognitive and behavioural deficits at the adult stage. Understanding mechanisms of harm will be paramount when developing interventions and hypotheses in future research.

1.8 Adolescent/Adult Differences

Clear indications of neuronal and developmental damage have been associated with alcohol use. Primarily, this body of work has taken place among adults but research examining the impact on adolescent brain structures is mounting. Both similarities and differences have been reported when comparing neuronal structures however,

adolescence presents a unique time of neuro-development and transition when compared to adults.

A systematic review of imaging studies examining brain structures in adolescents and young adults with alcohol problems reported observed differences in alcohol abuse and dependent individuals under 40 years of age, with 'uncomplicated' Alcohol Use Disorders (AUD) (Welch et al. 2013).

Hippocampal reductions are a common, well-documented structural feature in older adult alcoholics but this is not consistently demonstrated in adolescents. However, structural brain differences observed in adolescents are noted to have similarities, albeit in a more subtle way, when compared to adults (Sullivan and Pfefferbaum, 2005; De Bellis et al. 2000; Nagel et al. 2005.)

The very nature of adolescence as a time of experimentation, discovery and risk taking places the young person at heightened risk of several factors when compared to adults including, but not limited to; alcohol related motor vehicle crashes (Hingson et al. 2009; Hingson, Edwards and Zha, 2009), unintentional injuries (Hingson et al. 2003; Cherpitel, 2013) and risky sexual behaviours (Fergusson and Lynskey, 1996; Quigley and Marlatt, 1996; Smart, 1996; Thakker, 1998).

From a given volume of alcohol, young people are typically more vulnerable to its harms when compared to other age groups, and structural abnormalities of the brain have been found in young alcohol abusers (Hilton, 1987; Midanik and Clark, 1995; Makela and Mustonen, 2000).

1.9 Gender Differences

As previously highlighted, men reveal a far greater rate of total burden of disease attributable to alcohol when compared to women, and harmful use of alcohol remains a leading risk factor for death in males aged 15-59 (WHO, 2010). However, research has consistently reported that females are at heightened risk of alcohol related harm from a given level of alcohol use when compared to males (Medina et al. 2008; Caldwell et al. 2005; Spear, 2002; Tapert and Brown, 1999).

Although in its infancy, research examining gender differences in young people highlight some distinct differences between boys and girls when examining the impact of alcohol use.

Neuroimaging studies have highlighted significant differences in gray and white brain matter between males and females (Blanton et al. 2004). Females are consistently reported to demonstrate greater impairments in both neuropsychological functioning, and have revealed smaller gray matter volumes when compared to males (Medina et al. 2008; Caldwell et al. 2005; Schweinsburg et al. 2003).

Tapert and Brown (1999) studied a group of young people over an 8 year period into early adulthood and found females who had consumed alcohol exhibited greater levels of cognitive impairments in tasks of working memory and visuo-functioning, while males demonstrated a greater level of association between substance use and verbal learning skills. These findings were consistent with previous research in which females produced a greater number of perseveration errors compared to controls, while male

alcohol users demonstrated fewer errors in the same task when compared to controls. This not only contributed to the mounting evidence that females are more vulnerable to the effects of alcohol on neuropsychological functioning when compared to their male counterparts but that in females, frontal lobe functioning may be at greater risk of alcohol related impairments (Moss et al. 1994; Spear, 2002; Schweinsburg et al. 2003).

Researchers continue to speculate over structural differences and neuropsychological functioning reported in adolescent alcohol users. Factors, which are currently being explored, include gender specific brain development (Giedd et al. 1999; Lenroot and Giedd, 2006) and differential gene expression, which may be linked to greater levels of alcohol-related-neurotoxicity in females (Hashimoto and Wiren, 2008). Researchers have also suggested that heavy alcohol use in adolescence may contribute to hormonal dysregulation, which in turn, could impact on neuronal development and functioning (Tapert and Schweinsburg, 2005; Blakemore and Choudhury, 2006).

1.10 Characterisation

While there are several measures of alcohol consumption and heavy drinking which have been validated in adolescent populations, these often lack the fine-grained characterisation of drinking patterns. Such patterns might theoretically more likely lead to neuropsychological impairment in this group, when compared to the more typically described quantity-frequency measures of alcohol consumption. In particular, the concepts and terminology of 'binge' and 'heavy' drinking require better definition when applied to adolescent populations.

Several studies have examined the characterisation of adolescent drinking behaviours using latent class analyses. This provides a flexible methodology when examining both observed and latent variables, setting it aside from the more traditional analytical techniques. Earlier studies examining adolescent alcohol users, which have sought to categorise and define particular types of adolescent drinkers using a latent class analysis, while variable, are typically characterised by increasing consumption and associated risks.

Evidence from a latent class analysis taken from a US community sample of 16-20 year olds (n 4056), revealed a 3-class solution. It identified non-problem drinkers, which formed the majority of the sample (43%), regular drinkers (27%) and risky drinkers (30%), which were found to be the second largest class. While binge drinking and getting drunk were both prominent behaviours for both of the drinking groups, Reboussin (2006) highlighted that 'risky drinkers' were associated with drinking beliefs about friends drinking and getting drunk. This was further highlighted by Tomcikova (2011) and Jackson (2013) who reported 3 and 4 class solutions respectively, and similarly found that holding a positive attitude towards drinking, and perceived higher social support from other consuming peers and adults was associated with riskier drinking.

Echoing Reboussin's earlier results, Jackson (2013) also found that the largest proportion of the total sample (n 5018) was identified as the lower risk drinkers. An earlier study by Jackson (2008), which examined the predictive utility of different thresholds for heavy episodic drinking, for both proximal and distal outcomes, found a low to moderate threshold consistently predicted maximum drinks in the past month.

In addition to holding positive attitudes towards alcohol, a number of studies revealed early onset of alcohol use to be associated with problematic drinking. Using latent class analysis to characterise substance use, Pilatti (2003) examined the association between the age of drinking onset and substance using behaviours and revealed a 5-class solution. Adolescents with early drinking onsets were more likely to demonstrate heavier alcohol use, have more drunk episodes and more occasions of drug use than adolescents with later onsets. A later study by Reboussin (2006) also identified early drinking onset and other drug use as being associated with the 'risky drinkers' latent class.

Seigel (2011) reported results of a cluster analyses from a sample of 7723 12-18 year old students, which revealed riskier patterns of alcohol use associated with a decreased preference for malt beverages and wine coolers, and an increase in preference for spirits and beer in the older adolescent sample. The study highlighted a need for beverage preference to be captured in greater detail when collating data from young drinkers. Furthermore, that it may also prove beneficial to target interventions at younger adolescents to prevent, or minimise harm associated with transitions to more 'hard-core' alcohol and associated riskier drinking patterns.

Similarly in its infancy, research examining gender differences in young people has highlighted some distinctions between boys and girls when examining the impact of alcohol use. Studies examining gender differences when looking at the characterisation of drinking behaviours using latent class modelling, have reported mixed results. Chung (2001) examined the relationship between LCA and DSM-IV alcohol diagnoses and found a 3-class solution (asymptomatic, mild and severe) remained consistent across genders. Reboussin (2006) revealed males to be

associated with a risky drinking latent class, however an earlier study by Fergusson (1994), which examined a 4 class solution, correlations and comorbidities of a series of adolescent problem behaviours, found alcohol abuse to be an identified predominant problem behaviour in females. Research which applied latent growth mixture modelling to identify distinctive developmental trajectories of alcohol consumption in 14-18 year olds, reported evidence for 4 class gender specific alcohol trajectories to be mixed (Weisner, 2007).

Studies which have examined the characterisation of drinking behaviours in young people using latent class analyses have begun to explore the nature of alcohol use in young people by modelling patterns, providing an alternative to the more traditional one-dimensional measures and clinical criteria. Studies have suggested this could provide better understanding of the heterogeneous nature of underage drinking (Reboussin, 2006). Chung (2001) also highlighted that this approach may provide better coverage of symptomatic individuals compared with traditional DSM criteria, as latent class analyses are able to draw from both observed and latent indicators.

While latent class analyses present many strengths when examining the characterisation of drinking patterns, there are notable limitations highlighted in these previous studies. Key limitations of such studies lies in the self-reporting and recall bias of alcohol use by young people who may not wish to disclose actual consumption for fear of reprisal or, in contrast, individuals may over report if deemed more socially acceptable by peers (Jackson, 2013).

Varied outcomes and proposed patterns in this population have been found with the majority of studies reporting on US samples (Siegal, 2011; Reboussin, 2006; Chung,

2001) New Zealand (Jackson, 2013; Fergusson, 1994) and Europe (not including the UK; Weisner, 2007; Tomcikova, 2011), which may reflect different patterns of alcohol using behaviours pertinent to specific drinking cultures and acceptability of such behaviours, which may not be generalisable to the UK population.

Furthermore, studies are often limited to specific adolescent populations; secondary schools (Jackson, 2008; Pilatti, 2013; Tomcikova et al., 2011; Siegel, 2011) colleges (Beseler, 2012) and clinical (Chung, 2001). In addition to this, a number of studies select participants in the interest of specific risk factors associated with alcohol use (Pilatti, 2013; Kramer, 2007).

While studies may draw from measures of alcohol use validated for adolescents when establishing latent classes, a noted limitation has been that drinking behaviour questions could over estimate problematic drinking while others may minimise reports of AUD symptoms (Chung, 2001). Multiple methods in measuring consumption levels in this population could mean that latent class groups could alter depending on the method of classifying these variables. Similarly, broad measures of drinking such as, binge drinking could result in the combination of frequent drinkers with those who have low overall intake with occasional binges.

Furthermore, previous studies which are more commonly cross sectional in design, precludes determination of the direction of causation between predictors and drinking typologies, which highlights the need for future longitudinal studies which examine the course and development of adolescent drinking behaviours (Jackson, 2013).

1.11 Diagnostic Tools

In the eighteenth century and early nineteenth century alcoholic beverages were abundant and inexpensive, and alcohol consumption quickly established itself as a major public health issue, remaining so ever since. It was not until 1956 that 'alcoholism' was deemed a diagnosable illness within the medical field and this notion continues to evolve as understandings develop (Edwards, 1976).

From as early as the 18th century, public concern around alcohol and its excessive use were evident. Dr Benjamin Rush, Physician and Presbyterian minister was keen to highlight the demise of the alcohol consumer and advised people abstain from such beverages '*suddenly and entirely*'. Rush's '*campaign against spirituous liquors*', which was partly disseminated in the form of a public health information leaflet '*An inquiry into the effects of ardent spirits upon the human body and mind*' (Rush, 1785), sought to transform the public's relationship with distilled beverages.

Thomas Trotter's 1804 publication '*Essay, Medicinal, Philosophical and Chemical on Drunkenness and its Effects on the Human Body*', was an early example of the examination of the impact of alcohol on the human body. Trotter actively disassociated himself from the religious viewpoints and approaches to 'drunkenness' of the time, and instead drew from an empirical base. Trotter's research sought to highlight underlying mechanisms, observed symptoms of what is now understood as 'alcohol dependence' and alcohol 'induced' diseases which included, 'epilepsy, hysterics and convulsions', and was subsequently adopted by the medical professions. In addition to the physiological effects of alcohol, Trotter also noted the psychological impacts of alcohol use in humans, referring in his essay to '*the habit of drunkenness is a disease of the mind*' (Trotter, 1804).

Research and interest in the disease model mounted throughout the 18th century amongst medical professions, and early formulations of what was deemed 'alcoholism' were found in the early works of the biostatistician and physiologist Elvin Morton Jellinek. Jellinek proposed a series of 'alcoholic symptoms', which formed several typologies of alcoholism, which he believed an individual could experience on their road to alcoholism.

Jellinek's seminal work, 'Phases of Alcohol Addiction' was published by the World Health Organisation (Geneva WHO, 1952). The same year saw the American Psychiatric Association publication of the Diagnostic and Statistical Manual of Mental Disorders (DSM-I), include alcoholism as a diagnosable illness for the first time. Jellinek later extended his work to include a series of five 'species' or types of alcoholism. This included individuals who could be physically addicted with symptoms induced by alcohol use, including both physical and mental complications (Gamma category). There were also those individuals that were deemed psychologically addicted (Alpha category). Jellinek also maintained that there were individuals who did not present as physically, or psychologically dependent but who may experience a number of symptoms associated with alcohol use (Delta category). The final category was characterised by episodes of very heavy or binge type drinking (Epsilon category) (Jellinek, 1952).

The medical field increasingly supported alcoholism as a diagnostic construct, and with this came the need to develop empirically derived diagnostic measures. Between 1950 and 1970 Feighner and colleagues at Washington University developed the Feighner criteria, which aimed to establish a research base for psychiatric diagnostic criteria.

The Feighner criteria were derived from the work of Guze, Goodwin and colleagues (1962), who examined the prevalence of psychiatric illness in 223 male criminals. This included, 20 criteria for alcoholism formulated with the influence of Jellinek's earlier work. Feighner's 1972 paper defined 14 psychiatric conditions, which included alcoholism. Five phases were required in order to establish a diagnostic psychiatric illness which included, a clinical description, laboratory studies, delimitation from other disorders, follow up and family studies. The Feighner Criteria was renamed the Research Diagnostic Criteria in 1975.

The works of Edwards and Gross (1976) sought to clarify clinical understandings and promote the continuing review of scientific evidence in the formation of new diagnostic criteria. Their work came to focus on alcohol dependence when they presented the concept of the 'Alcohol Dependence Syndrome', which comprised of several elements, presented in varying degrees *'thus giving the syndrome a range of severity'* (Edward and Gross, 1976). Edward and Gross identified 'essential elements' and repeated patterns which are evident in dependent drinkers including, narrowing of drinking behaviours, heightened tolerance to alcohol, repeated withdrawal symptoms, relief and avoidance of withdrawal effects by further drinking, compulsion to drink and reinstatement after abstinence. Their work, which also highlighted differences between the biologically driven concepts of 'alcohol dependence' 'from' alcohol abuse/harmful use, proved highly influential in the 2nd revision of the DSM in 1980, where 'alcoholism' was replaced with two categories; 'alcohol dependence' and 'alcohol abuse' under a new diagnostic category of 'substance use disorders'. Revisions in 1987 and 1994 extended the category of alcohol dependence to include individuals who may not meet dependence criteria per se, but who continue to use alcohol, albeit with harms related to its consumption including, social, interpersonal and legal problems.

The latest revision of the DSM (DSM V; American Psychiatric Association, 2013) combines 'alcohol dependence' and 'alcohol abuse' into a single disorder, 'alcohol use disorder' (AUD). The severity of the disorder is deemed 'mild, moderate or severe' as a result of the number of symptom criteria met in the previous 12 months (Appendix 1)

At the same time the DSM was establishing its diagnostic criteria, the World Health Organisation (WHO) developed the International Classification of Diseases (ICD) in order to collate data on the causes of death and illness including, those related to alcohol dependence and abuse (ICD; WHO 1949). It was not until 1967 that 'alcoholism' was included in the index and was categorised alongside personality disorders and neuroses. 1979 saw the second edition (ICD-9), which also introduced the separation of alcoholism into 'alcohol dependence' and 'alcohol abuse', in an attempt to collate data, which reflects health problems associated with alcohol consumption.

Both editions of the DSM and ICD continue to develop, and undergo revisions in a coordinated effort in order to advocate for consistency worldwide.

1.12 Identification and Diagnostic Assessments of Alcohol Use

Disorders in Children and Young People

DSM and ICD criteria were developed for the assessment of psychiatric diagnoses in adult populations, and research has highlighted significant limitations in the application of this in the adolescent population. A number of the diagnostic symptoms, which are assessed in the formulation of diagnoses, could be deemed as being developmentally normative for adolescents, and may be over endorsed leading to distorted clinical

understandings of adolescent alcohol use. Another substantial limitation of the criteria is the inclusion of several symptoms, which would not typically be experienced by adolescent alcohol users. Adolescents may not identify with clinical terminology, which may be used as part of the assessment process i.e. physiological components of 'withdrawal' may be less comparable to an adolescent's experience of a 'hangover'. As such, clinicians/professionals engaging individuals in discussions around alcohol use, which could over look, or simply be unable to capture the sensitivities of the patterns of adolescent use. Furthermore, symptoms including tolerance, withdrawal and alcohol related medical problems are associated with a substantial period of heavy drinking less likely to be observed in younger drinkers.

Clinical assessment remains varied across the UK, and in addition to the diagnostic 'checklist', clinicians are reminded that physical, psychological and social functioning components should also be incorporated into the assessment of an individual's alcohol use.

Assessments examining alcohol use in adolescents are also varied. Clinical screening instruments are used to determine any presence of problematic alcohol use. A positive screen informs the use of more comprehensive assessments, which employ diagnostic interviews to assign AUDs and assess severity and the nature of alcohol problems (NICE, 2011). While clear diagnostic criteria traditionally may have been established using comprehensive measures of alcohol use disorders, self-report measures can often provide information which standardised assessments are unable to capture, although the same reports are often scrutinised over the subject of validity.

In 2011 the National Institute for Health and Clinical Excellence (NICE) commissioned the National Collaborating Centre for Mental Health (NCCMH), who specialise in the development of NICE mental health clinical guidelines, to review tools for case identification and assessment of alcohol problems in children and young people (NCCMH, 2011).

The Guideline Development Group (GDG) found the Alcohol Use Disorders Identification Test (AUDIT) (Babor et al. 2001) to be appropriate for case identification in young people with adjusted cut off score of 4 or more (Chung et al. 2000; Kelly, 2002, Coulton, S. et al. 2016).

The GDG went on to systematically review a series of clinical tools, which were able to provide a comprehensive assessment of alcohol use and misuse in children and young people. Three clinical tools were identified: Adolescent Drinking Index (ADI; Winters and Henly, 1993), Diagnostic Interview Schedule (DISC; Piacentini et al. 1993) and Teen Addiction Severity Index (T-ASI; Kamier et al. 1991).

The ADI outcome was established using the DSM-III-R psychiatric diagnosis of alcohol abuse or dependence in 12-18 year olds, in addition to psychosocial stressors, cognitive impairments and social functioning and takes approximately 50 minutes to complete. Research highlights good inter-rater reliability (alcohol abuse 0.86, alcohol dependence 0.53), test re-test reliability (0.83), significant concurrent validity among all variables (0.58 to 0.76), adequate criterion validity assessed by a clinician rating alcohol abuse ($k=0.71$), alcohol dependence ($k=0.82$), high sensitivity and specificity for both alcohol abuse (both 0.87) and dependence (0.90 and 0.95 respectively) (Winters and Henly, 1989; Winters et al. 1993).

The DISC has demonstrated high sensitivity in the identification of young people with substance use disorders based on the DSM-V criteria (75%) (Fishcer et al. 1993). Researchers have noted that despite the reporting of acceptable reliability and validity, this has been for non-substance specific psychiatric disorders and as such may impact on its appropriateness of use in children and young people (Jenson et al. 1995; Piacentini, 1993; Schaffer et al. 1996; Schwab-Stone et al. 1996). A further limitation may be the length of the assessment being 1-2 hours.

The T-ASI is a semi structured clinical interview, which contains 126 items, which indicates severity ratings for psychoactive, substance use, school/employment status, family and social relationship, legal and psychiatric status. The T-ASI demonstrates satisfactory inter-rater reliability ($R=0.78$) and highlights its capacity to both identify alcohol abuse and dependence, as well as assess severity in response to clinical interventions (Kaminer et al, 1991). A later study found the T-ASI was able to differentiate between 12-17 year olds who presented with, or without a DSM-III-R defined substance use disorder (Kaminer et al. 1993).

The NICE GDG highlighted that clinical tools should be used and interpreted by trained staff and that assessment of alcohol use and misuse in children and young people should incorporate other co-morbid and social problems, development needs, educational and social progress and motivation in addition to the overall assessment of risk and presence of AUD diagnostic criteria. It was also stipulated that in the assessment and treatment of alcohol problems in children and young people that treatment goals should be abstinence focused (NCCMH, 2011).

1.13 Policy and Strategy

1.13.1 WHO Global Strategy

In May 2010 The World Health Organisation established a Global Strategy to Reduce the Harmful Use of Alcohol. This strategy seeks to guide countries and policy makers in utilising the evidence base in the establishment of effective policy responses to harmful alcohol use and related harms.

The strategy highlights a number of challenges and opportunities faced across the world including, establishing an appropriate balance between public health, wellbeing and economic interests. This balance goes further in terms of a widening discrepancy between increasing availability and affordability of alcohol and a countries capacity to manage this additional health burden.

Research and mounting evidence in this area may prove beneficial to the advancement of health policies and the promotion of the wellbeing of a nation however, this often originates from high income countries which may no translate to all settings and as such, there is a need to focus on the dissemination of new findings in health inequalities among groups particularly effected including, minority or marginalised groups.

The strategy highlights 10 'target areas' which encourage member states to incorporate into their health policies including; leadership, awareness and political commitment, health services response, community action, drink driving policies and counter measures, availability of alcohol, marketing of alcohol, pricing policies, reducing the

negative impacts of alcohol consumption and intoxication, reducing the public health impact of illicit alcohol and monitoring and surveillance.

The strategy states that the protection of vulnerable populations at greater risk to alcohol related harms should form an integral component of health policies aimed at reducing harmful alcohol use.

1.13.2 UK Drinking Guidelines for Adults

UK Government guidance on the consumption of alcohol did not come into effect until 1984 in the form of a health information leaflet '*That's the limit*', which defined 'safe limits' for alcohol consumption in men as being no more than 18 'standard drinks' and 9 for women. The term 'standard drink' was later defined in 1987 as 1 unit of pure alcohol. These guidelines were formally endorsed by the Royal College of General Practitioners, the Royal College of Physicians and the Royal College of Psychiatrists (RCGP, 1987; RCP, 1987; RCPsych, 1986).

The guidelines were reviewed in the early 1990s in wake of evidence, which suggested that low-level daily consumption of alcohol offered a level of protection against Cardiovascular Heart Disease mortality, and guidelines were amended to daily limits of 3-4 units for men and 2-3 units for women. It also advised the public to ensure at least 2 alcohol free days each week. These new 'sensible drinking' guidelines were used to establish targets which aimed to reduce the harmful use of alcohol and were captured within the 'Health of the Nation' strategy (DoH, 1995). The Royal Colleges also reviewed the emerging evidence and maintained that the 1987 guidelines were 'sufficient' which prompted a disparity in opinions and remains a disputed area within research and policy, An inquiry report published in 2012 was tasked with reviewing UK

alcohol guidelines and highlighted 'significant concerns'. As a result of this inquiry a working group proposed, in addition to the current guidelines, that the public should be advised to incorporate 2 alcohol free days each week and that the current drinking limits should not be increased.

Overall, it was concluded that the UK drinking guidelines and limits set were 'about average' when compared with other developed nations. The working group went on to stress the importance of drinking guidelines, which reflect the social objectives when advising the public on the safer use of alcohol, with the aim to reduce harm caused as a result of hazardous use.

More recently, the UK drinking guidelines underwent a review by 3 independent groups who examined the evidence on the health effects of alcohol. The outcome of this review resulted in new weekly guidelines which recommended no more than 14 units per week for both men and women and that consumption should be spread over 3 days or more. The review also recommended that 'single drinking episodes' should be limited in the total consumed, slowly and with food (DoH, 2016)

1.13.3 Adolescent Guidelines

It was not until 2009 that guidelines were established for children and young people (Donaldson, 2009), and current UK Guidelines promote the healthiest option as being an alcohol free childhood. The guidelines also recommend that if a young person chooses to consume alcohol it should not be done until age 15 or older, not exceeding adult daily unit recommendations and on no more than one occasion per week (Donaldson, 2009).

1.13.4 what is a Unit?

In the UK a unit of alcohol equates to 8 grams of pure ethanol, which is approximately 10ml. A unit of alcohol is the amount of alcohol in which an adult can process within a 1-hour period. However, this becomes more complex with the differing strengths of alcoholic beverages available, in addition to the differing processing time according to the individual i.e. having smaller BMI.

Alcohol Beverage Volume (ABV) is typically used to construe the strength of alcohol. For example a 750ml bottle of wine has an Alcohol Beverage Volume of 12%. This amounts to 12% of the bottle contents being pure alcohol, which equates to 90ml or 9 units in total. (House of Commons Science and Technology Committee, 2011)

1.2 Research Aim

Many of the criteria used for alcohol disorders have been largely developed and standardised on adult clinical populations (Slade et al. 2013). Subsequently, studies have shown that criteria may perform differently across age groups, particularly when developmental, personality and social factors are considered. Research has highlighted limited empirical support in the application of diagnostic criteria in adolescents among the general population (Deas, 2000). Limitations similarly exist in the psychometric components of these criteria when applied to adolescents who use alcohol (Chung and Martin, 2002; 2005, Mewton et al. 2011).

While there are several measures of alcohol consumption and heavy drinking which have been validated in adolescent populations, these lack fine grained characterisation of drinking patterns which might, theoretically more likely lead to neuropsychological

impairment in this group compared to more typically described quantity/frequency measures of alcohol consumption. In particular, the concepts and terminology of 'binge drinking' and 'heavy drinking' require better definition when applied to adolescent populations. Adolescents may not identify with terminology often used with the more traditional measures i.e. physiological components of 'withdrawal' may be less comparable to an adolescent's experience of a 'hangover'. As such, clinicians/professionals engaging individuals in discussions around alcohol use may overlook, or simply be unable to capture the sensitivities of the patterns of use in the early days of an adolescent's relationship with alcohol.

There is a need to identify distinctive alcohol drinking patterns, or profiles in adolescents that consider multivariate indicators instead of the more traditional quantity/frequency measures, which were predominately developed for the adult population.

Several studies have examined alcohol use patterns in adolescents using latent class and cluster analyses. The varied outcomes and proposed patterns of these population's drinking behaviours, and lack of consensus on such solutions highlight the research gap and clinical need to establish a well-characterised and validated multi-dimensional measure of drinking patterns based on empirical research.

This study provides a unique opportunity to draw from an unusually large cohort of adolescent heavy drinkers and controls from two well established research programmes within the National Addiction Centre, and Social, Genetic and Developmental Psychiatry (MRC), totalling 7000 adolescents across 4 European countries. This project has the opportunity to examine this international cohort at a developmentally crucial time in adolescence.

The opportunity to examine early neurocognitive changes associated with alcohol use in a large cohort of adolescents (10-17 years) could provide a better understanding of the early onset of 'alcohol induced neuropsychological impairments'. This could subsequently be used to inform alcohol consumption guidelines and practice to improve outcomes and prevent or reduce alcohol use and harm in this population when reversibility of harm may still be possible.

1.3 Study Aims

This series of studies aims to provide novel information on the relationship between alcohol consumption and neuropsychological functioning in adolescents, furthering understanding of alcohol related risk behaviours, drinking patterns, characteristics and prevalence in this population. This thesis will describe patterns of alcohol consumption in the developmentally sensitive period of 10-17 years, apply sophisticated methods of latent variable modelling to identify distinct groups of individuals, characterised by drinking patterns, who may be at increased risk of experiencing alcohol related harm and examine neuropsychological correlates.

It is this opportunity to identify early neurocognitive changes associated with alcohol use in a large cohort of adolescents which could provide a better understanding of the early onset of 'alcohol induced neuropsychological impairments' which could subsequently be used to inform alcohol consumption guidelines and practice to improve outcomes, and prevent or reduce alcohol use and harm in this population when reversibility of harm may still be possible.

Advancing our knowledge in the characterisation of adolescents alcohol use and identifying any differences in neuropsychological functioning can contribute to the

development and formulation of new guidelines and interventions in the prevention or reduction of alcohol involvement in this population.

1.4 Hypotheses

This cohort of adolescents is likely to report considerable variation in the quantities, frequencies and beverage types consumed, which will lead to the formulation of distinctive drinking profiles.

Key alcohol related indicators will be used in the establishment of distinct drinking profiles, or characterisation of adolescents who use alcohol, reflecting severity of use. These characterisations will be used to identify subsets of adolescents who differ in their risks of experiencing alcohol related health and social consequences. Furthermore, these subsets of young alcohol users, in addition to health and social consequences, may also demonstrate differences in individuals neuropsychological functioning. This can offer valuable insight into how the early characterisation and establishment of such drinking profiles could translate as the young person transitions into adulthood.

Chapter 2 Methods

2.1 Introduction

This thesis draws on two existing studies, SIPS Junior a screening and prevalence survey of alcohol consumption and alcohol use disorders in adolescents attending Emergency Departments and IMAGEN a European research project examining risk taking behaviours in teenagers (www.sips.iop.kcl.ac.uk www.imagen-europe.com). These are both large datasets with a combined cohort of approximately 7000 adolescents from across 4 European countries.

This chapter will summarise the methodology used throughout this cross sectional design study, in addition to the formulation of a series of latent class studies and subsequent multivariate analyses, detailing the study design, sample, measures used, procedures, statistical analyses and its strengths and limitations.

2.2 Sips Junior Research Programme

The NIHR funded SIPS Junior programme is a Survey of Adolescent Lifestyle and Health prevalence study of alcohol consumption and alcohol use disorders. The study will integrate multiple metrics of alcohol use in adolescents into a number of latent classes, which will provide a full characterisation of drinking patterns reflecting increasing severity of alcohol use. The relationship between beverage choice latent classes and demographics, harm indicators and drinking outcomes will also be examined.

2.2.1 Participants

Participants were aged between their 10th and 18th birthdays attending one of 10 Emergency Departments (ED) across 3 regions in England; North East, Yorkshire and Humberside, London.

Five Thousand adolescent ED attenders were screened to establish the prevalence of alcohol consumption, drinking related problems and AUDs (alcohol abuse and dependence).

Participants who were alert, orientated and able to speak sufficient English in order to complete the research assessments were deemed eligible for inclusion. Participants were not eligible for inclusion in the study if they were suffering from a serious mental health problem, had a severe injury, were grossly intoxicated or if they, their parent or guardian were unable/unwilling to provide informed consent to take part.

The following studies included data for those participants reporting that they had consumed alcohol in the previous 90-day period.

The original study received ethical approval from National Health Service Research Ethics Committee London – Camden and Islington 12/LO/0799. ISRCTN: 45300218.

2.2.2 Procedure

Adolescent ED attenders who met the study criteria, and who were cleared by the ED clinical staff were approached by a researcher and invited to take part in the study. Before informed consent was obtained, participants and, where appropriate, parents or guardians were given a study information sheet and the opportunity to ask any questions. Participants and parents, or guardians were informed that as part of the informed consent procedure that the participants use of alcohol would not be disclosed

to their parent/guardian or ED staff without their consent. If participants were under the age of 16, and unaccompanied by a parent or guardian, Gillick competencies were assessed by a member of ED staff when taking informed consent for participation (15.Gillick v West Norfolk & Wisbech Area Health Authority) (Appendix 4).

Once informed consent was obtained participants were taken to a private area of the ED to complete the research interview independently, with the researcher available to support if required.

All study data remained anonymous and participants completed questionnaires via an electronic tablet device, with a researcher at hand to support where needed. The Time Line Follow Back questionnaire was completed through an interview with the researcher. On completion of the research questionnaires the participants were returned to the care of the ED staff or parent or guardian. Participants were issued a £5 gift voucher to thank them for taking part in the study. If participants had reported alcohol consumption during the completion of the questionnaires they were issued with age appropriate reading material pertaining to alcohol use, which also contained information on local support services/help lines which could provide additional support if required (Appendix 5).

2.5 Measures

The current study utilises a series of measures collated from the original research programme and included the following;

2.5.1 Demographics

Age, gender, location and ethnicity were collected in addition to information on general health behaviours and lifestyle including tobacco smoking.

2.5.2 Alcohol Use

Participant's who reported having consumed alcohol in their lifetime, the age of first consumption was noted. They were then asked as to whether they had consumed alcohol in the past 3 months and previous 24 hours.

2.5.3 Alcohol Intoxication

Questions from the European School Survey Project on Alcohol and Other Drugs (ESPAD, 2011) were asked of participant's who reported having consumed alcohol in their lifetime, this included question 19 ("experienced alcohol intoxication in their lifetime?") and question 21 ("personal experience of alcohol?") of the European School Survey Project on Alcohol and Other Drugs (ESPAD, 2011; Hibell et al. 2009) (Appendix 6).

Participant's who indicated that they had consumed alcohol that was 'more than a sip' in the past 3 months were asked additional alcohol specific questions:

2.5.4 Alcohol Related Consequences

Consequences of alcohol consumption were assessed by ESPAD question 22, "Because of your own alcohol use, how often during the last 12 months have you experienced the following?" (Appendix 6).

The ESPAD has been found to have a good level of test-retest reliability and concordance in answers related to alcohol use (Molinoro et al. 2012).

2.5.5 Alcohol Use Disorders Identification Test (AUDIT)

The Alcohol Use Disorders Identification Test (AUDIT) (Babor et al. 1992) was developed by the World Health Organisation as a screening measure for the hazardous consumption of alcohol (Saunders et al. 1993). The AUDIT was used to identify hazardous alcohol use, in addition to alcohol use and dependence among participants.

The AUDIT-C is brief validated screening tool for hazardous drinking, which comprises of the first 3 questions of the full 10 item AUDIT questionnaire. The measure has been validated in adolescent populations in the ED in the United States (Chung et al. 2000; Kelly, 2002) and its performance has not been found to differ on sensitivity and specificity when compared to other screening tools including the full AUDIT, Problem Oriented Screening Instrument for Teenagers (POSIT) and CRAFTT. A recent study using the SIPS Junior dataset used as part of this theses, reported that a cut off score off score of 3 or more in the AUDIT-C demonstrated significantly better sensitivity (89%; 86 to 91%) and negative predictive value (98%; 96 to 98%) when compared to the full AUDIT, with good diagnostic properties for the identification of heavy episodic alcohol consumption in adolescents (Coulton et al. 2016). A cut-off of score of 3 or more was used throughout these studies.

	AUDIT	Scoring System				
		0	1	2	3	4
AUDIT-C Questions	How often do you drink alcohol?	Never	Monthly or less	2-4 times per month	2-3 times per week	4+ times per week
	How many units of alcohol do you drink on a typical day when you are drinking?	1-2	3-4	5-6	7-9	10+
	How often have you had 6 or more units if female, or 8 or more if male, on a single occasion in the last year?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
	How often during the last year have you found that you were not able to stop drinking once you had started?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
	How often during the last year have you failed to do what was normally expected of you because of your drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
	How often during the last year have you needed an alcoholic drink in the morning to get yourself going after a heavy drinking session?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
	How often during the last year have you had a feeling of guilt or remorse after drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
	How often during the last year have you been unable to remember what happened the night before because you had been drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily
	Have you or somebody else been injured as a result of your drinking?	No		Yes, but not in the last year		Yes, during the last year
	Has a relative or friend, doctor or other health worker been concerned about your drinking or suggested that you cut down?	No		Yes, but not in the last year		Yes, during the last year

Scoring: 0 – 7 Lower risk, 8 – 15 Increasing risk, 16 – 19 Higher risk, 20+ Possible dependence

Figure 2 Alcohol Use Disorders Identification Test

2.5.6 DSM-IV and ICD-10 diagnoses of alcohol use disorders

The MINIKID is a structured clinical assessment designed to assess the presence of DSM-IV and ICD-10 psychiatric disorders in children and adolescents aged 6 to 17 years. Four screening questions are administered to participants, and a positive screen results in additional symptom specific questions being administered (Sheeham et al. 2010).

Diagnoses of Alcohol Use Disorders were derived from the MINIKID alcohol use criteria to assess age appropriate DSM-IV criteria (Sheehan et al. 2010) (Appendix 7).

2.5.7 Beverage-Specific Quantity-Frequency (BSQF).

Participant's reported types of beverage consumed over a 90-day period. Data was obtained using the Beverage-Specific Quantity-Frequency (BSQF) measure of alcohol consumption. This measure is derived from methods used to measure consumption in adolescent populations (Hibell et al. 2009), and conforms to European guidance on the standardisation of measurement consumption. The BSQF measures total quantity and frequency of consumption of specific beverages and episodes of excessive consumption over a 90-day period (Appendix 8).

2.5.8 Timeline Follow-Back (TLFB)

The TLFB is a retrospective interview conducted by a trained researcher, which seeks to ascertain actual alcohol consumed over a 90-day period. This measure has been validated for use in adolescent populations (Brown et al. 2000; Donoghue et al. 2004), and collated data on participant's total consumption in standard drinks, percentage of

days abstinent, standard drinks per drinking day and days of excessive drinking over a 90-day period (Sobell et al. 1992).

For the purpose of this study quantity of alcohol consumed in the past 90 days was derived from the TLFB and converted to standard units where one unit was the equivalent of 8g of pure ethanol.

While both the AUDIT-C and BSQF are self-completed instruments, a trained researcher conducted the TLFB with the participant (Appendix 9).

2.5.9 Health Related Quality of Life

Kidscreen

The Kidscreen questionnaire was used to assess participant's quality of life. For the purpose of this study Kidscreen-10 (Ravens-Sieber, et al. 2010) was used. This version is developed from the longer Kidscreen-52 and contains 10 items, which measures 5 quality of life domains including, physical wellbeing, psychological wellbeing, autonomy and parent relation, peers and social support and school environment. Each item is answered using a 5-point scale and higher values indicate a better quality of life.

Studies have shown the KIDSCREEN-10 to achieve similar levels of validity for the majority of the items tested and that although limited, a correlation of 0.91 between the KIDSCREEN-10, and KIDSCREEN-52 demonstrates a common general HRQoL underlying factor in the single dimensions are well represented. Overall, the Kidscreen-10 has established validity and reliability in this population (Ravens-Sieberer et al. 2010) (Appendix 10).

2.5.10 Behavioural and Emotional Functioning

Strengths and Difficulties Questionnaire (SDQ)

Behavioural and emotional functioning was measured using the Strengths and Difficulties Questionnaire (SDQ) (Goodman et al. 1999; Muris et al. 2004). This is a brief 25-item scale covering four domains including, emotional symptoms, conduct problems, hyperactivity-inattention, peer problems and pro-social behaviours and has been found to discriminate well between children with and without psychopathological symptoms (Goodman, 1999; Godman et al. 1998; Klassen et al 2000; Muris, Meesters and Van der Berg, 2003) (Appendix 11).

In addition to the analyses from the SIPS Junior dataset, this thesis will also be drawing from a second large-scale European wide research project examining risk-taking behaviours in teenagers. This study is described below.

2.6 IMAGEN

IMAGEN is a major European Commission funded project, which aims to identify and learn more about biological and environmental factors that might have an influence on mental health in teenagers (Schumann, et al. 2010). A total of 2000 14 year olds were recruited across 4 countries (England, Ireland, France and Germany) and analysed with functional and structural neuroimaging and experimental tasks measuring individual differences in brain, cognitive and behavioural responses in reward, punishment, risk taking, impulsivity, novelty seeking and attention control of emotional processes.

2.6.1 Participants

Participants were aged 14 and recruited from across 4 European countries (England, Ireland, France and Germany). Participant's were recruited from high schools equally targeted which included, private, state funded and special units

Participant's were 14 years of age and attended a high school in one of the 4 European countries included in the study; England, Ireland, France and Germany.

Two thousand participants' and their parents/guardians consented to taking part in the study. Participant's who were alert and orientated were deemed eligible for inclusion. Participant's were not eligible for inclusion in the study if they met any of a series of exclusion criteria including, but not limited to pre-natal alcohol use exposure (>210ml per/week), premature birth, diabetes, epilepsy, head trauma, hearing/vision difficulties, IQ<70, treatment for schizophrenia and bipolar disorders, magnetic resonance contraindications or if they, their parent or guardian were unable/unwilling to provide informed consent to take part.

Recruitment criteria were maximised in two key areas; ethnic homogeneity in order to reduce stratification effects for genetic analyses and sample diversity including social economic status, academic achievement and emotional/behavioural functioning.

2.6.2 Procedure

The study was promoted in high schools in addition to a study website which contained full explanations of the study procedures including, a short film which described the

DNA sampling and neuroimaging assessment. For those participant's who expressed an interest in taking part in the study, information packs were provided. These packs contained questionnaires collating personal data and consent forms for both the adolescent and parent/guardian.

Once informed and consent had been obtained, family ID codes were assigned to each case. Furthermore, parent/guardians were required to complete screening questionnaires, which reviewed the inclusion/exclusion criteria. Additional screens took place on the day of neuroimaging (Appendix 12).

The battery of assessments for the study was made available online for participants to complete. Some research centres chose to administer the tests in class wide assessment sessions.

Some measures were completed on the day of the neuroimaging assessment, which included the Development and Wellbeing Assessment (DAWBA), Strengths and Difficulties Questionnaire (SDQ) (Appendix 11) and Time Line Follow Back (TLFB) (Appendix 9) which were administered by trained researchers. On the day of assessment parents completed an additional battery of questionnaires, which covered personality, substance use, domestic conflict, and family history of psychiatric problems.

2.7 Measures

2.7.1 Development and Wellbeing Assessment (DAWBA)

The DAWBA is a series of questionnaires, rating scales and interviews, which are conducted with 5 – 17 year olds and can also be collated from parents and teachers.

The battery of assessments is designed to generate ICD-10 and DSM-IV psychiatric diagnoses covering common emotional, behavioural and hyperactivity disorders. Questions cover the criteria for several psychiatric diagnoses including; separation anxiety, specific phobia, social phobia, panic disorder, PTSD, general anxiety disorder, major depression, ADHD/hyperkinesis, conduct disorder, eating disorders, pervasive developmental disorders, tic disorders and bipolar disorders.

Results from the battery assessment are inputted into a computer algorithm, which predicts the likelihood of the clinical rater, assigning ICD-10 or DSM-IV criteria. Each participant is assigned to one of 6 probability bands ranging from <0.1% likely to >70% likely. The clinical rater then reviewed the data obtained and decided on definitive diagnoses where applicable (Appendix 13).

2.7.2 Strengths and Difficulties Questionnaire (SDQ)

Behavioural and emotional functioning was measured using the Strengths and Difficulties Questionnaire (SDQ) (Goodman et al. 1999; Muris et al. 2004). This is a brief 25-item scale covering four domains including, emotional symptoms, conduct problems, hyperactivity-inattention, peer problems and pro-social behaviours and has been found to discriminate well between children with and without psychopathological symptoms (Goodman, 1999; Godman et al. 1998; Klassen et al. 2000; Muris, Meesters and Van der Berg, 2003) (Appendix 11).

2.7.3 Alcohol Use Disorders Identification Test (AUDIT)

The Alcohol Use Disorders Identification Test (AUDIT) (Barbor et al. 1992) has been previously described in this chapter and as such will not be repeated here.

2.7.4 European School Survey Project on Alcohol and Other Drugs (ESPAD)

Participant's who reported having consumed alcohol in their lifetime were asked question 19 ("experienced alcohol intoxication in their lifetime?") and question 21 ("personal experience of alcohol?") of the European School Survey Project on Alcohol and Other Drugs. Consequences of alcohol consumption were assessed by ESPAD question 22 "Because of your own alcohol use, how often during the last 12 months have you experienced the following?" (ESPAD, 2011; Hibell et al. 2009) (Appendix 6).

2.7.5 Time Line Follow Back (TLFB)

The TLFB has previously been described in this chapter and as such will not be repeated here (Appendix 9).

Several of the measures used in the analyses for the SIPS Junior dataset are also captured within the IMAGEN dataset. Lists of measures for both studies are displayed in the table below.

Variables	SIPs Jr	IMAGEN
Gender	✓	✓
Age	✓	✓
Socio-economic status	✓	✓
Family (divorced parents? Siblings?)	-	✓
Height	-	✓
Weight	-	✓
Smoking status	✓	✓
Physical activity	-	
Drug Use	-	✓
Age of onset	✓	✓

Duration of use (yr/mths)	✓	✓
TLFB	✓ (90 days)	✓ (30 days)
Frequency of intoxication episodes	✓	✓
Alcohol free days	✓	✓
Beverage preference	✓	✓
Max daily alcohol intake	✓	✓
AUDIT	✓	✓
Attention/Inhibition CANTAB: Rapid visual Info Processing	-	✓
Visuo-Spatial CANTAB: Spatial Working Memory	-	✓
Memory CANTAB: Pattern Recognition	-	✓
Affective/Impulsivity CANTAB: Go-No-Go	-	✓
Decision/Risk Taking CANTAB: Cambridge Guessing Task	-	✓
Purdue Pegboard Dexterity Test	-	✓
Intelligence and Global Functioning WISC-IV	-	✓
MINIKID	✓	
Strengths and Difficulties Questionnaire	✓	✓
KIDSCREEN	✓	
Beverage Specific Quantity-Frequency (BSQF)	✓	-
EPSAD Q's: 19-21, 22	✓	✓
Neo-PI-R	-	
Temperament and Character Inventory	-	✓
Substance Use Risk Profile Scale	-	✓
Michigan Alcoholism Screening Test	-	✓

Monetary Choice Questionnaire	-	✓
Emotional Dot Probe	-	✓
Morphed Faces Task	-	✓
Passive Avoidance Learning Paradigm	-	✓
The Development and Wellbeing Assessment Interview	-	✓
Conflict Tactics Scale	-	✓
Genetic Screening and Family History of Psychiatric Disorders Interview	-	✓
Childhood Trauma Questionnaire	-	✓
Puberty Development Scale	-	✓
Pregnancy and Birth Questionnaire	-	✓

Table 1: Variables from the SIPS Junior and IMAGEN datasets. Measures included in studies highlighted in **bold**.

2.8 Neuropsychological Functioning

2.8.1 Cambridge Neuropsychological Test Automated Battery (CANTAB)

The CANTAB is a battery of computerised cognitive assessments, which have shown strong correlations to brain constructs, in addition to having a high level of sensitivity to changes over time. There are 25 cognitive tests, which examine several areas of cognitive function which include; general memory and learning, working memory and executive function, visual memory, attention and reaction time, semantic/verbal memory and decision making.

2.8.2 Affective Go-No-Go (AGN)

The affective go-no-go task assesses participant's information processing biases for positive and negative stimuli. Participants are presented with a series of stimuli in

which they are required to respond to 'go' cues as rapidly as possible and infrequent 'no-goes' which participants are required not to respond. The task also includes affective set shifting of attention when the target category changes during the task.

2.8.3 Cambridge Gambling Task (CGT)

The Cambridge Gambling Task assesses six areas of participant's decision-making processing including, risk taking, quality of decision-making, deliberation time, risk adjustment and delay aversion (Rogers et al. 1999; Deakin et al. 2004). Participants are presented with a series of red and blue boxes and guess whether a yellow token is in a red or blue box. Participants are issued a number of points as part of the task and then use these points to gamble on their chance of getting the task correct.

2.8.4 Pattern Recognition Memory (PRM)

Pattern Recognition Memory is a test of visual pattern recognition memory in which participants learn a set of 12 coloured visual patterns, which are presented for 3 seconds on a screen. These patterns in addition to new unseen distractor patterns are presented and participants are required to identify the correct pattern, which they have previously seen.

2.8.5 Rapid Visual Information Processing (RVP)

Rapid Visual Information Processing is used to assess participant's level of sustained attention including, response accuracy, target sensitivity and reaction times. A series of digits appear in a random order and participants are required to press a response pad when they see one of 3 sets of number sequences (3-5-7, 2-4-6, 4-6-8).

2.8.6 Spatial Working Memory (SWM)

Spatial Working Memory assesses participant's ability to retain and manipulate visuospatial information. Five white squares appear in different locations on a screen for 3 seconds. Participants are presented with two white squares and they identify the original location of the white square, this is repeated a total of 3 times with new locations.

Cognitive Domain	CANTAB Test
Memory	Paired associates learning (PAL) Delayed matching to sample (DMS) Graded naming test (GNT) Pattern recognition memory (PRM) Spatial recognition memory (SRM) Verbal recognition memory (VRM) Spatial span (SSP) Spatial Working Memory (SWM)
Attention	Reaction time (RTI) Rapid visual information processing (RVP) Choice reaction time (CRT) Simple reaction time (SRT) Match to sample visual search (MTS) Attention switching task (AST)
Executive Function	One touch stockings of Cambridge (CTS) Attention switching task (AST) Stockings of Cambridge (SOC) Intra-extra dimensional set shift (IED) Spatial Span (SSP) Spatial working memory (SWM) Stop signal task (SST)
Decision Making	Cambridge gambling task (CGT) Affective go-no-go task (AGN) Information sampling task (IST)
Social Cognition	Emotion recognition task (ERT)

Table 2: The Cambridge Neuropsychological Test Automated Battery (CANTAB); Cognitive domains and neuropsychological tests. Those used in IMAGEN highlighted in **bold**.

The IMAGEN study selected clinical and self report measures based on 3 criteria; validation across three languages, validation for use with adolescents and suitability for electronic assessment. A pilot study was conducted in 3 centres to develop and test measures. The cognitive/neuropsychological functions related to reward sensitivity, cognitive control and emotional reactivity (Schumann et al. 2010).

For the purpose of this study all CANTAB measures that were used as part of the IMAGEN study were used.

2.9 Data Analysis

2.9.1 Structural Equation Modelling (SEM)

SEM stems from path analysis (Wright, 1921) and is a modelling technique, which aims to understand patterns and covariance, while examining networks of relationships between both measured (observed) and latent (unobserved) variables. This statistical technique draws particular interest when examining theoretical constructs due to its ability to incorporate latent factors within its analyses.

The incorporation of both observed and latent variables with potential direct and indirect paths can lead to complex models. Unlike traditional statistical methods SEM draws on a number of statistical tests when determining model fit.

2.10 Statistics

2.10.1 Latent Class Analysis (LCA)

LCA is a probabilistic model, which provides a way to identify a set of discrete mutually exclusive latent classes, which are characterised by multiple dimensions (Muthen & Muthen, 2000).

Chapters 3 and 4 will present a series of LCA which will examine whether qualitatively distinct subgroups of adolescents (10-17 years) attending emergency departments (ED) in England can be identified on the basis of a limited number of drinking indicators, which will include, beverage type, onset, consumption, intoxication, AUDIT-C and drinking days.

Chapters 5 and 6 will examine as to whether latent class structures formulated in these earlier chapters can adequately represent the heterogeneity in drinking behaviours in a European sample of 14 year olds. Multivariate analyses will examine associations between latent class membership and neuropsychological functioning.

In this instance LCA enables the identification of underlying subgroups within the adolescent population characterised by different patterns of alcohol use, drawing from multiple observed and latent categorical indicators. In dichotomising the endorsement profiles (beverage type, onset, consumption, intoxication, AUDIT-C and drinking days), each variable was considered individually and the most efficient method of dichotomisation selected to maintain the interpretability of the results.

Endorsement profile variables were dichotomised using the mean split. Using a median split, while often considered when using non-normal variables, can lead to significant loss of power, as data is split into three groups; those below the median, those at the median and those over the median, with only the first and last groups included in the analysis. Consequently, this could result in a considerable loss of power in these samples.

While the dichotomisation methods are different when using median/mean splits, the group allocation remains the same. For example, intoxication, the median value is 1, so a two group median split would place all those who scored 0 and 1 in one group and all those who scored greater than 1 in the other. The mean is 1.55 so a mean split would put all participants who scored 0 or 1 in one group and all those who scored greater in the other.

Research has found LCA to be particularly useful when exploring the multidimensional nature of substance use. Furthermore, LCA is considered to be person centred in its approach in that, individuals are examined with regards to their heterogeneity in their responses to multiple observed and latent categorical indicators, which results in latent classes characterising profiles which individual class members share (Collins and Lanza, 2010).

Differences in adolescent alcohol use and misuse are more commonly determined with the use of cut off scores, which could lead to crude associations between individuals who may share similar scores on a psychometric assessment, but similarities in their profiles may end there, which could lead to classification errors. Classification errors may not only lead to difficulties in the estimation of prevalence of alcohol use in

adolescents, but may also in turn have detrimental impacts for the design and implementation of interventions (Solberg and Olweus, 2003).

LCA is exploratory in its nature, and irrespective of what can be learnt about the predictors of alcohol use in adolescents, as with any predictive model any associations that are highlighted cannot be interpreted as being causal in nature. Consequently, any interventions developed using this information are unlikely to be entirely effective (Lanza, 2013).

Nonetheless, LCA has many advantages including, that while dependence between indicators in the sample data is expected within latent classes it is assumed that indicators are independent and that the latent class variables account for these interrelations (Hox, 2010).

In addition to the estimation and model fit indices previously described, LCA also produces outcomes, which can provide insight into the latent class properties, these include, Item Probabilities, which are the probability of each indicator being endorsed by an individual, and Class Probabilities, parameters that describe the relative size of the latent classes.

LCA are initially conducted on two class models, and subsequently followed by a series of models with an increasing number of classes in each, until a model is found with the best fit for that data. Each model is evaluated by a series of model fit indices and comparisons using the information criterion previously outlined to determine the best-fit latent class model. Models are evaluated in terms of how well individual class

membership can be predicted in addition to how well classes can be distinguished from each other. Models with lower information criteria values are preferred.

Due to the exploratory nature of these analyses, outcomes are also considered whether models and their associated latent classes reflect logical patterns, which capture meaningful profiles and how readily these solutions can be interpreted. It is also important to ensure that no one class is too small in size relative to other classes.

Analyses aim to establish a set of distinctive homogeneous classes whereby differences are assumed to be a result of random measurement error (McCutcheon et al. 1987; Magidson and Vermunt, 2000), and that co-occurrence of key indicators and associated patterns and covariance are evidence of an underlying class structure within the data set. Once models with best-fit are identified a series of regressions can be used to examine the associations between the identified latent classes and potential determinants. Once these analyses are complete and latent classes are fully established, probabilistic models then allow for the model to be replicated with an independent sample (Muthen and Muthen, 2000).

Once the model with best fit to the data is identified, a series of multivariate analyses including, logistic and multinomial regressions are used to examine the associations between the identified latent classes and potential determinants including, demographics, harm indicators and drinking outcomes. Further post hoc tests will be used to examine any areas/latent class of particular interest.

2.11 Estimation and Model Fit

SEM can use the maximum likelihood (ML) estimation, which assumes that the sample data being analysed follows a multivariate normal distribution of an adequately sized sample. When examining goodness of fit indices it is also important to ensure the better fit model, should it be on par with an alternative, that the simpler of the two is preferred. In SEM goodness of fit measures also include the Chi Square and Degrees of Freedom when considering the fit of the model.

2.11.1 Chi Square Test

Values close to zero indicates a small level of difference between the expected and observed co variances matrices, and is also indicative of a better model fit. When the chi-square is close to zero the probability level required is greater than 0.05.

2.11.2 The Comparative Fit Index (CFI)

The CFI is a model fit index, which compares the model with the performance of a baseline, or null model. The CFI is a popular statistic in SEM as it performs well with smaller samples (Tabachnick and Fidell, 2007). CFI values range between zero and 1 whereby, a value of 0.90 or greater indicates an acceptable model fit (Hu and Bentler, 1999).

2.11.3 Root Mean Square Error Approximation (RMSEA)

RMSEA is often used as a supplementary fit index when accommodating large data sets (Steiger and Lind, 1980), and favours models with the fewest number of parameters. RMSEA values range between zero and 1 with smaller values indicating a better model fit. A value of ≥ 0.95 is indicative of good fit (Hu and Bentler, 1999).

2.11.4 Akaike Information Criteria (AIC)

The AIC is derived from Information Theory and estimates the quality of each model relative to other models for a given data set.

AIC is twice the chi square, minus the degrees of freedom for the model (Hox, 2010). A perfect fit of the model would result in a value of 1. General consensus, although this is often debated, is that a value of at least 0.80 is deemed adequate to accept the model while, 0.85 would be considered a 'good' model fit.

2.11.5 Bayesian Information Criteria (BIC)

Both the AIC and BIC are used to both estimate the quality of models relative to each other and as a means to estimate the generalisability of models to fit other data sets.

The BIC is often favoured in large samples and resolves issues around overfitting models when adding parameters by including a larger penalty, when compared to the AIC, for the number of parameters included in the model

2.11.6 Entropy

The entropy of a model is used to determine the level of classification uncertainty in a random variable. This is scored on a scale between 0 and 1 in which values greater than 0.80 indicating a good level of separation between the identified classes (Ramaswamy et al. 1993).

2.11.7 Modification Indices

Modification indices can be produced in SEM software packages in order to improve the fit of the model whereby, parameters that are not significant are deleted and alternative parameters are introduced. Identified parameters are freed and those which produce the greatest improvement in the model fit remain, this is repeated with other parameters until the most superior model fit is obtained. However, this method will also result in 1 degree of freedom being lost (Lanza, 2013).

2.12 Strengths

SEM presents numerous strengths when conducting exploratory analysis drawing on multivariate techniques, which use both, observed and unobserved variables. This sets it aside from the more traditional analysis techniques, which only use measured variables. Furthermore, SEM has very few limitations with regards to associations that can be specified in the models. SEM provides a flexible methodology when examining this research area.

LCA lies within the realm of SEM and shares a number of its strengths already highlighted. It provides a comprehensive way of identifying a set of underlying subgroups, which do not require the inclusion of standardised variables, and is inclusive of both predictor and outcome variables in the formulation of the model. When examining behavioural phenomena such as alcohol use in young people an advantage of the LCA technique is that it is person centred in its nature, it has the ability to examine individuals in terms of their similarities and differences both within and between their subgroups.

2.13 Limitations

Statistical approaches that use categorical data require careful re-coding of continuous data to ensure that categories remain meaningful and do not result in a substantial loss of information. Furthermore the selection of variables to be included in any analyses are dependent on what that researcher believes to be of important in the exploration of their research area, as such, marked differences can present in the formulation of drinking typologies, which can make drawing comparisons with other studies troublesome.

The flexibility of LCA can be viewed equally as a limitation, as it can a strength. While useful in the exploration of behavioural phenomena this can equally result in researchers imposing their own restrictions on the data, which in turn can lead to compromised data. Furthermore, mindfulness is needed when generating hypotheses and research questions to ensure these are not formulated in order to conform to the data available. This is particularly pertinent when using secondary data; however, large data sets, such as those described in this research programme, provide a rich opportunity to further our understanding of, in this case, alcohol use in adolescents.

Chapter 3 Beverage Preferences in Adolescents Attending Accident and Emergency Departments in England and Related Harms: A Latent Class Analysis.

3.1 Introduction

When examining young people's alcohol consumption, research indicates that adolescents tend to drink more than one type of alcoholic beverage, with observed gender differences in beverage preference (Fuller, 2013). An annual survey of young peoples' (11 – 15 years) drinking behaviours reported 38% of pupils having ever consumed alcohol in 2014, demonstrating a downward trend from previous years. However, prevalence continues to increase with age and average weekly consumption in 2014 was 9.8 units. This varies considerably with 22% of pupils having consumed at least 15 units in the previous week (Fuller et al. 2015).

As seen worldwide, most alcohol consumed by young people in the UK is in the form of beer, lager or cider and research reports that these drinks are more likely to have been consumed in the previous week (72%), when compared to spirits (59%), alcopops (40%) and wine (38%). These proportions were also similar when examining levels of consumption with beer, lager and cider accounting for 5.5 units in the previous week and less than half of this total reported in the form of spirits (1.7 units), wine (1.7 units), and alcopops (1.3 units) (Fuller et al. 2015).

Girls were observed to consume more beer, lager and cider than other beverage types although, boys were observed on average to consume more beer units than girls (7.1 units compared with 1.4 units). Girls were also noted to consume more spirits (73% of girls, 45% of boys) and wine (48% and 28% respectively) when compared to boys,

which, reflects the proportions of beverage types consumed in adult females, although these differences were not significant (Fuller et al. 2015).

Research suggests that drinking more than one type of alcohol can itself increase a young person's risk of harmful drinking compared to those who only consume one type of alcoholic beverage (Ramstedt et al. 2011). Room and colleagues (2011) found that young people, who did not have a clear preference for a beverage type, and were more likely to switch between drink types, could translate into being lighter and less frequent drinkers in fact, emerged as the more 'problematic' drinkers.

Research is yet to establish consistent large differences between beverage types and related harms, although small-observed differences may highlight indicators of difference with regards to spirit consumption, with a greater implication in fatal alcohol poisonings (Makela et al. 2007). Research tends to support the notion that young people's beverage choice will be influenced by an individual's motives, which in turn may account for how this beverage is used, with subsequent implications for outcomes (Borsari et al. 2001; Donovan et al. 2004; Martin et al. 2006; Bremner et al. 2011).

The examination of preference and difference between beverage types and alcohol related harms continue to be explored. Disparate findings further highlight this research gap, particularly for young drinkers. Much of what is known with regards to different beverage types, impacts derived from adult populations and differences between adults and young people's alcohol use can mean that findings may not translate to young people's alcohol preferences and drinking behaviours.

Differences observed both in the choice and response to alcohol use may be a reflection of the individual's characteristics and motivating factors, but may also reflect an association of beverage types with certain drinking patterns in young people. What

may differentiate young people from adults when considering this is the likelihood that any drinking patterns can be very unstable and susceptible to external influences (Kraus et al. 2010).

There is a need to identify distinctive alcohol drinking patterns or profiles in adolescence that considers multivariate indicators in addition to the more traditional quantity-frequency measures.

Few studies have examined alcohol use patterns in adolescent's using latent class analysis (LCA). In addition to this, lack of consensus on such solutions demonstrate the need for further LCA research to better establish the number of latent classes which might be expected in particular populations (Kuvaas, 2014).

3.2 Aim

This study applied latent class analysis (LCA) to indicators of beverage choice to examine whether qualitatively distinct subgroups of adolescents could be identified on the basis of their use of different beverage types. The relationship between beverage choice latent classes, demographics, harm indicators and drinking outcomes were also examined.

3.3 Methods

3.3.1 Participants

Participants were aged between their 10th and 18th birthdays attending one of the 10 participating Emergency Departments (ED) across England; North East, Yorkshire and Humber and London. To be eligible for inclusion in the research programme,

participants had to be alert, orientated and able to speak sufficient English to complete the research assessments. Participants were not eligible for inclusion if they had a severe injury, were suffering from a serious mental health problem, grossly intoxicated or if they, their parent or guardian were unable or unwilling to provide informed consent to take part. The current study included the data for those participants reporting that they had consumed alcohol in the previous 3 months (n 1360). A total of 49.8% of the sample were male (n 677) and 50.2% (n 683) were female. The mean age of the sample was 13.28 years (SD 2.07). The mean age of initiation of alcohol was 12.90 years (2.18).

3.3.2 Measures

For the purposes of the current study demographics including age, gender and ethnicity were collected. Participants were asked questions about their alcohol use in the previous 3 months and the consequences associated with its use, these questions included; questions 19-21-22 from the ESPAD Study (ESPAD, 2011) (Hibell et al. 2009), Strengths and Difficulties Questionnaire (SDQ) (Goodman et al. 1999; Muris et al. 2004), the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al. 1993), Timeline Follow-Back (TLFB) (Sobell et al. 1992), the Mini International Neuropsychiatric Interview for Children and Adolescents (MINIKID) (Sheehan et al. 2010) and the Beverage-Specific Quantity-Frequency (BSQF). The AUDIT-C has been validated in adolescent populations in the ED in the United States (Chung et al. 2000; Kelly 2002), and was used to identify hazardous drinking using a cut-off of 3, in-line with the findings of the SIPS Junior study (Coulton et al. 2016). A trained researcher conducted the Time Line Follow Back (TLFB) interview covering the past 90 days (Sobell et al. 1992). The TLFB has been validated for use in this population (Brown et al. 2000; Donoghue et al. 2004) and involves a retrospective interview to ascertain actual alcohol consumed over a 90-day period, total consumption in standard drinks,

percentage of days abstinent, standard drinks per drinking day and days of excessive consumption.

A trained researcher conducts the TLFB, whereas both AUDIT-C and BSQF are self-completed instruments. Diagnosis of alcohol use disorder (AUD) will be derived from the MINIKID alcohol use module to assess age-appropriate DSM-IV criteria.

Beverage type indicators were obtained from the Beverage Specific Quantity-Frequency (BSQF) measure of alcohol consumption, derived from methods used to measure consumption in adolescent populations, and conforms to European guidance on the standardisation of measurement of consumption (Hibell et al. 2009). The BSQF measures total quantity and frequency of consumption of specific beverages and episodes of excessive consumption over a 90-day period.

3.4 Statistical Analyses

Using data from the SIPS Junior Research Programme, dichotomous indicators of beverage type (beer, cider, alcopops, wine, spirits), derived from the BSQF measure were used to formulate latent classes of beverage preference in adolescents. All analyses were conducted separately for males and females.

All data was cleaned and prepared for analyses in SPSS Version 22 (SPSS inc, 2013), while Latent Class Analyses and multinomial regressions were performed in Mplus Version 7.2 (Muthen and Muthen, 2012).

Analyses were conducted for a two-class model which were followed by a series of models with increasing number of classes in each, up to a total of 6, to find a model

that provided the best level of fit to the data. Each model sought to create empirically derived classes or groups of adolescent drinkers, based on indicators of beverage type consumed in the previous 3 months.

Each model was subsequently evaluated by a series of model fit indices and comparisons using information criterion to determine the best-fit class model. Models were evaluated in terms of how well individual class membership could be predicted, in addition to how much the classes could be distinguished from each other. Models with the lower values are preferred and information criteria was used to determine this were; the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Chi-Square (X^2) Degrees of Freedom and entropy.

In addition to the model parameters identified, analyses also considered whether models and their related classes reflected a logical pattern, in which meaningful profiles or labels could be attached and how readily this solution could be interpreted. It was also important to ensure that no one class was too small in size relative to other classes.

Analyses aimed to establish a set of distinctive homogeneous classes whereby, differences are assumed to be a result of random measurement error (McCutcheon et al. 1987; Magidson and Vermunt, 2000), and that co-occurrence of beverage type, associated harm indicators and outcomes of harm are evidence of an underlying class structure within the data set.

Once the model with best fit to the data was identified, a category logistic regression was used to examine the associations between, the identified latent classes and potential determinants including, demographics, harm indicators and drinking outcomes.

3.5 Results

A total of 5576 participant's consented to take part in the original research trial, 1342 (24.7%) of whom reported having consumed alcohol in the previous 3 months, 668 (49.8%) male and 674 (50.2%) female. The majority of the sample reported their ethnicity as White n 1110 (86.5%) and n 879 (67.8%) reported living in the South of England (Appendix 11).

A total of 76% of the sample (n 1025) reported having consumed their first alcoholic drink before the age of 15 years. The mean age of initiation of alcohol use was 12.88 years (SD 2.19). The average unit consumption for the previous 28 days measured by the TLFB was 10.93 units (SD 25.80), this was slightly higher in females 11.09 (SD 24.92) when compared to males 10.77 (SD 26.67). However, males reported drinking more, on days when they did drink alcohol (7.47 units, SD 8.19) compared to females (6.55 units, SD 6.71).

Approximately, half of the sample (49.5%) scored 3 or more on the Alcohol Use Disorders Identification Test - Consumption (AUDIT-C), which is indicative of increasing risk and higher risk drinking. The Mini International Neuropsychiatric Interview for Children and Adolescents (MINIKID) Alcohol Abuse Criteria was met by 0.52 % of the alcohol user sample (n=7), females n=2 (0.14%) and males n=5 (0.37%),

equal numbers of males and females met the criteria for dependence, total alcohol users n=12 (0.89%) and n= 6 (0.44%) for both genders. Females were more likely to report having been intoxicated in the previous 30 days n 153 (11.6%) compared to males n 118 (9.0%). Over a quarter (n 369, 26.8%) reported having ever smoked tobacco, with a higher proportion evident in females (n 214, 15.5%) compared to males (n 155, 11.3%).

3.5.1 Prevalence of and associations between use of beverage types

Over half of the sample (52%) reported having consumed beer in the previous 3 months. Spirits were the second most consumed beverage type (46.7%) followed by cider (40.6%), alcopops (35.9) and wine (26.8%).

Binary logistic regressions were conducted to identify whether any associations between beverage types existed. Associations between beverages types could contribute further to formulations examining indicators of beverage type consumption in adolescents.

Males

Beer consumption had the greatest level of association with wine when compared to other beverage types and was not found to be significantly associated with cider, alcopops or spirits. Spirit consumption was associated with cider and alcopops. There were no associations found between cider and wine or alcopops, or between alcopops and wine. Table 3 provides an overview of beverage type associations consumed in the previous 3 months.

	Over the past 3 months did you consume (Yes)	Beer/ Lager	Cider	Alco pops	Spirits	Wine/ Sherry
Beer /Lager	463 70.8%	-	-	-	-	-
Cider	269 41.3%	1,098 (.995- 1.018)	-	-	-	-
Alcopop	153 23.4%	0,895 (0.786- 1.018)	1.049 (0.849- 1.296)	-	-	-
Spirits	275 42.2%	0.880 (0.757- 1.023)	1.221 (1.016- 1.466)	1.515 (1.148- 2.000)	-	-
Wine/ Sherry	275 41.2%	1.186 (1.077- 1.306)	.847 (.649- 1.106)	0.766 (0.507- 1.157)	1.176 (0.944- 1.465)	-

Table 3: Past 3 months male alcohol beverage type consumption N (%) and associations between beverage types expressed as odds ratios (OR) and 95% Confidence Intervals (CI)

Females

Beer consumption had the greatest level of association with cider when compared to other beverage types and was also associated with wine. Spirit consumption was associated with cider and wine. There were no associations found between cider and wine or alcopops but in contrast to males, there was an association between alcopops and wine. Table 4 provides an overview of beverage type associations consumed in the previous 3 months.

	Over the past 3 months did you consume (Yes)	Beer/Lager	Cider	Alco pops	Spirits	Wine/Sherry
Beer/Lager	237 (35.6%)	-	-	-	-	-
Cider	273 (41.2%)	1.647 (1.382-1.964)	-	-	-	-
Alcopop	327 (49.3)	1.065 (0.909-1.248)	0.963 (0.821-1.129)	-	-	-
Spirits	344 (52.0)	1.124 (0.915-1.381)	1.342 (1.161-1.550)	1.055 (0.903-1.232)	-	-
Wine/Sherry	241 (36.5%)	1.308 (1.133-1.510)	0.868 (0.705)	1.238 (1.009-1.518)	1.171 (1.011-1.356)	-

Table 4: Past 3 month female consumption by beverage type N, (%), and associations between beverage types expressed as odds ratios (OR) and 95% Confidence Intervals (95%)

3.5.2 Model Selection

A series of 2-5 latent class models were fitted to the data on beverage type using MPLUS. Table 5 and 6 provides an overview of the model fit parameters for 2-4 latent class models for the indicators of beverage type in adolescent males and females, respectively. Models were compared in order to select the model with the best fit to the available data.

3.5.2.1 Males

Model fit indices for the male latent class analysis are shown in Table 3. The AIC indicated a superior fit for a 2-class model (AIC = 2001.940), compared to a 3-class model (AIC = 2002.684) and 4-class model (AIC = 2004.710). The BIC similarly suggested a 2-class model was superior (BIC = 2044.091), compared to a 3-class model (BIC = 2067.826) and 4-class model (BIC = 2092.843). A 5-class model could

not be adequately identified with the available data, and analyses did not support a single maximum likelihood solution.

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	2001.940	2044.091	37.560	20	0.731
3	2002.684	2067.826	24.637	14	0.805
4	2004.710	2092.843	11.331	8	0.609

Table 5: Model fit indices for male latent class analysis of beverage types (SIPS Jr)

Table 5 details the degrees of freedom and Likelihood Ratio, which demonstrate, whether the proposed model is superior to the null model. In addition to these results, entropy results suggested that a 3-class model had a higher level of classification certainty (entropy = 0.805), with results greater than 0.80 indicating a good separation of the identified classes when compared to other models (2 class model 0.731, 4 class model 0.609). This was further supported by greater levels of average latent class probability demonstrated in the 3-class model (class 1 probability 1.000, class 2 0.991, class 3 0.787), when compared to 2 class average latent class probabilities (class 1 0.918, class 2 0.785) and the 4-class model (class 1 0.796, class 2 0.690, class 3 0.718, class 4 0.831) (Appendix 14).

Close examination of the 2, 3 and 4 class model solutions and evaluation of the model fit indices led to the selection of a 3 class model for male adolescents. The model selection combined the results of the model indices, in addition to how well the model

reflected classes, which were realistic and meaningful in the context in which the data has been examined.

3.5.2.2 Females

Model fit indices for the female latent class analysis are shown in Table 5. The AIC indicated a superior model for a 3-class model (AIC = 4507.050), compared to a 2-class model (AIC = 4515.915) and 4-class model (AIC = 4511.147). In contrast, the BIC suggested a 2-class model was superior (BIC = 4565.706), compared to a 3-class model (BIC = 4584.000) and 4-class model (BIC = 4615.257). As demonstrated in the male sample, a 5-class model could not be adequately identified with the available data for females and analyses did not converge on a single maximum likelihood solution.

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	4515.915	4565.706	43.365	20	0.704
3	4507.050	4584.000	22.499	14	0.733
4	4511.147	4615.257	14.597	8	0.588

Table 6: Model fit indices for female latent class analysis of beverage types (SIPS Jr)

Table 6 includes results of the degrees of freedom and Likelihood Ratio, which demonstrates whether the proposed model is superior to the null model. In addition to these results, the entropy result suggested that a 3-class model had a higher level of classification certainty (entropy = 0.733) when compared to other models (2 class model 0.704, 4 class model 0.588). Greater levels of average latent class probabilities were demonstrated in the 3-class model (class 1 probability 0.924, class 2 0.775, class 3 0.931) when compared to 2 class average latent class probabilities (class 1 0.777,

class 2 0.948) and the 4-class model (class 1 0.682, class 2 0.789, class 3 0.871, class 4 0.510)

Close examination of the 2, 3 and 4 class model solutions and evaluation of the model fit indices led to the selection of a 3 class model for female adolescents. The model selection combined the results of the model indices, in addition to how well the model reflected classes, which were realistic and meaningful in the context in which they were examined (Appendix 15).

Parameters that are able to discriminate within a Latent Class Analysis are important when selecting models, those that are able to establish distinctive patterns of endorsement of the indicators of interest across all classes. As is the case with Information Criterion values, which are not tests of significance but one of a number of parameters, which seek to present the model with the best approximation to 'reality'. As such, 3 class models were found to provide the best fit for both male and female adolescent beverage type consumption in the previous 3 months. The symptom endorsement parameters for the 3-class model in males and females are provided in figures 1 and 2 respectively.

3.5.3 Symptom endorsement profiles for 3 class model

Figures 1 and 2 provide symptom endorsement probability profiles for the 3 class models for both males and females. The symptom endorsement profiles for males and females presented clear distinctions between the two classes in the previous 3 months.

3.5.3.1 Males

Figure 3 portrays the endorsement probabilities for males, and revealed a high level of similarity between each of the 3 classes. Class 1 (29.9% of male drinkers) had the lowest prevalence of beer (17.9%) compared to class 2 (28.7%) and class 3 (24.2%). In addition to this, Class 1 had the highest level of endorsement probability of alcopops (10.1%), compared to class 2 (7.5%) and class 3 (5.8%). Class 2 (37%) had the highest level of endorsement probability for cider (19.2%) and beer (28.7%) compared to class 1 (17.9% and 11.7% respectively) and class 3 (24.2 and 10.4 respectively). Class 3 (32%) with the exception of beer (24.2%) contained the lowest level of symptom endorsement probability across all other beverage types (Appendix 16).

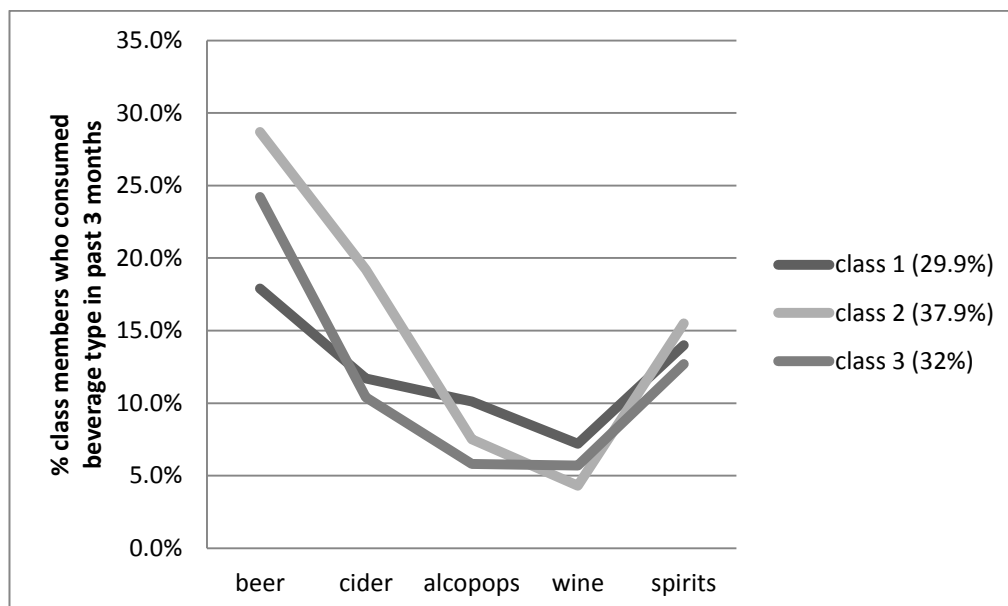


Figure 3: Symptom endorsement profile for male beverage preference latent classes

3.5.3.2 Females

Figure 4 presents the symptom endorsement probabilities for female beverage type consumption. In contrast to the male classes, Latent Class Analysis identified distinct profiles of beverage consumption in the female 3-class model. Class 1 contained over half (56.1%) of the female sample and was characterised by the highest level of

endorsement probability for all beverage types; beer (19.1%), cider (21.4%), alcopops (26.1%), spirits (26.6%) with the exception of wine (12.4%). Class 2 (17.6%) was the smallest of the classes and with lower levels of probability symptom endorsements for alcopops (10.7%), wine (8.0%), and spirits (12.5%). Class 3 was characterised by the higher level of symptom endorsement for wine (16.2%) and the lowest level of symptom endorsement for beer (6.8%) and cider (8.6%)(Appendix 17).



Figure 4: Symptom endorsement profile for female beverage preference latent classes

3.5.4 Latent Class Profile Demographics

3.5.4.1 Males

Of the study sample of 668 males who had consumed alcohol in the previous 3 months, 209 (29.9%) were assigned to latent class 1, which contained the fewest number of males compared to other male classes. The mean age of this class was 13.16 years (SD 1.95). A total of 153 (76.5%) reported having consumed alcohol

before the age of 15 years and the mean age of first alcohol use was 12.37 years (SD 1.72). A total of 161 (80.50%) reported being of White ethnicity and 28 (14%) Other ethnicity (Black 4.50%, Chinese 0%, Mixed 4.00%, Asian 2.51%, Other 2.16%). A total of 89 (44.5%) participants in class 1 scored 3 or more on the AUDIT C, which is an indicator of hazardous drinking (Appendix 18).

Class 2 was the largest of the male latent classes 253 (37.4%) with a mean age of 12.94 years (SD 1.75). A total of 187 (27.99%) of the class reported having consumed alcohol before the age of 15 and the mean age of initiation of alcohol use was 12.23 years (SD 1.59). A total of 213 (31.89%) of the class reported being of White ethnicity and 26 reported Other (Black 1.19%, Chinese 0%, Mixed 0.75%, Asian 0.59%, Other 1.19%). A total of 127 (19.01%) scored a total of 3 or more of the AUDIT C (Appendix 18).

Class 3 contained 215 (31.8%) participants and had a mean age of 12.59 (SD 2.20). 187 (27.99%) participants reported having first consumed alcohol before the age of 15 years. The mean age of initiation of alcohol use was 12.34 (SD 1.72). 181 (27.09%) reported White ethnicity and 23 reported Other (Black 1.35%, Chinese 0%, Mixed 1.19%, Asian 0.15%, Other 0.45%). A total of 127 (19.01%) of class 3 scored 3 or more on the AUDIT C, indicating hazardous use of alcohol (Appendix 18).

3.5.4.2 Females

Of the 674 female participants, 383 (56.3%) were assigned to latent class 1. This was the largest of the female classes in which almost three-quarters (74.6%) reported having consumed alcohol before the age of 15 years. The mean age of this class was 13.16 years (SD 1.95). The mean age of initiation of alcohol use was 12.37 years (SD

1.72). A total of 314 (82.85%) of the class members reported White ethnicity and 56 (14.76%) Other Ethnicity (Black 6.59%, Mixed 4.49%, Asian 1.85%, Other 1.85%). 172 (45.38%) of latent class 1 members scored a total of 3 or more of the AUDIT C, which is an indicator of hazardous alcohol use (Appendix 19).

Class 2, the smallest of the female latent classes 119 (17.5%) of which, 94 (83.93%) reported consuming alcohol before the age of 15 years. The mean age of this class was 12.94 years (SD 1.75). The mean age of alcohol initiation for participants in latent class 2 was 12.23 years (SD 1.59). The majority (89.29%) were of White ethnicity while 12 (10.71%) were of other ethnicity (Black 6.25%, Chinese 0%, Mixed 2.67%, Asian 0%, Other 1.79%). Over half of the female latent class sample (59.82%) scored a total of 3 or more on the AUDIT C (Appendix 19).

Class 3 contained 178 (26.2%) of female participants of which, 134 (19.9%) reported having consumed alcohol before the age of 15 years. The mean age of this class was 13.03 years (SD 2.15). The mean age of alcohol initiation for this class was 12.26 years (SD 1.55). A total of 141 (79.66%) reported White ethnicity, 28 (15.82%) reported other ethnicity (Black 7.90%, Chinese 0%, Mixed 5.08%, Asian 1.13%, Other 1.69%). Over half of the class (51.41%) scored a total of 3 or more on the AUDIT C (Appendix 19).

3.5.5 Latent class beverage unit consumption

Average total units for each beverage type consumed in the previous 3 months were captured by the BSQF q 1-4 which provided information on the quantity (standard units), as opposed to type of alcohol consumed by participants. Results indicated that for both males and females there was wide variation in the quantities consumed which,

in turn were not necessarily reflective of the probability of beverage type endorsements calculated through the latent class analysis.

As expected with this population there were high levels of variation of consumption across classes evidenced in large standard deviations (SD). Distinctive differences remained evident between males and females with regards to the levels of consumption of each beverage type.

3.5.5.1 Males

Male participants across all classes were most likely to report having consumed beer in the highest level of quantities over the previous 3 months. Average unit consumption for this period was 47.48 units (SD 224.19). This was followed by spirits, 46.91 (SD 380.12), cider 26.53 (SD 211.84), wine 8.43 (SD 119.25) and alcopops 3.25 (SD 13.62).

	Class 1 209 (29.9%)	Class 2 253 (37.4%)	Class 3 215 (31.8%)	Total Mean (SD)
Beer, Mean (SD)	31.63 (122.28)	40.68 (229.34)	67.86 (278.28)	47.48 (224.19)
Cider, Mean (SD)	19.73 (152.18)	47.76 (324.57)	10.70 (40.05)	26.53 (211.84)
Alcopops, Mean (SD)	2.76 (6.57)	1.91 (5.90)	5.03 (21.29)	3.25 (13.62)
Wine, Mean (SD)	1.12 (3.76)	19.03 (197.16)	3.54 (22.12)	8.43 (119.25)
Spirits, Mean (SD)	11.49 (32.85)	111.64 (636.80)	12.44 (41.54)	46.91 (380.12)

Table 7: Male 3 Class Model: Average Beverage Type Unit Consumption (SD)

Class 1

In contrast to the endorsement probabilities for beverage type consumption seen in the male classes portrayed in Graph 1 within class 1, beer had the highest average unit consumption in the previous 3 months, 31.63 units (SD 122.28) (Table 7). This was the lowest level of consumption when compared to class 2, 40.68 units, (SD 229.34) and 3 67.86 units (SD 278.28). Beer was reported as having the lowest level of endorsement when examined using latent class analysis (Graph 1). Cider demonstrated the second highest level of average unit consumption within class 1, 19.73 units (SD 152.18), followed by spirits, 11.49 units, (SD 11.49) and wine 1.12 units (SD 3.76) - which were the lowest average level of consumption across the male classes, and alcopops.

Class 2

Class 2 revealed the highest level of average spirit consumption in the previous 3 months 111.64 units, (SD 636.80), which does not reflect the level of probability reported in Graph 1 and was significantly higher when compared to class 1 (11.49 units, SD 32.85) and 3 (12.44 units, SD 41.54). Class 2 revealed beer (40.68 units, SD 229.34) and cider (47.76 units, SD 324.57) as having the highest level of endorsement probability of having been consumed. These were reported as the second and third highest level of consumption after spirits for this class. Class 2 also had the highest level of cider and wine consumption when compared to other male classes (Table 7).

Class 3

Class 3 with the exception of beer, contained the lowest level of symptom endorsement probability across all other beverage types. When the average unit consumption for the same period was examined, beer was identified as having the highest average

level of unit consumption both within and across the male classes (67.87 units, SD 278.28). In addition, alcopop unit consumption was also noted to have the highest level across classes (5.03 units, SD 21.29) (Table 7). Relative to other classes and with the exception of beer, lower levels of average unit consumption were noted across all other beverage types, which may reflect the reported lower probabilities of symptom endorsement portrayed in the latent class analysis for this class.

3.5.5.2 Females

Female participants were found to have consumed greater quantities of spirits, (33.84 units, SD 275.73) in the previous 3 months when compared to other beverage types, cider (28.35, SD 213.27), wine (14.91, SD 114.50), beer (14.65, SD 83.84), alcopops (5.23, SD 12.11). When compared to male participants, females consumed higher levels of cider, (28.35, SD 113.26) alcopops (5.23, SD 12.11) and wine (14.91, SD 114.50) in the same 3-month period.

	Class 1 383 (56.3%)	Class 2 119 (17.5%)	Class 3 178 (26.2%)	Total Mean (SD)
Beer, Mean (SD)	7.76 (33.93)	48.59 (185.66)	5.89 (13.99)	14.65 (83.84)
Cider, Mean (SD)	8.13 (23.27)	109.21 (487.72)	16.15 (87.78)	28.35 (213.26)
Alcopops, Mean (SD)	4.26 (9.55)	8.59 (18.49)	12.39 (41.82)	5.23 (12.11)
Wine, Mean (SD)	12.39 (41.82)	115.32 (619.40)	18.262 (64.39)	14.91 (114.50)
Spirits, Mean (SD)	3.39 (22.36)	55.69 (257.60)	10.61 (43.69)	33.84 (275.73)

Table 8: Female 3 Class Model: Average Beverage Type Unit Consumption (SD)

Class 1

While spirits were the most endorsed beverage type in female class 1, when consumption was examined it revealed that wine had the highest level of unit consumption compared to other beverage types within class 1 (12.39 units, SD 41.82). Cider was the second most consumed beverage type (8.13 units, SD 23.27), followed by beer (7.76 units, SD 33.93). Alcopops and spirits were the least endorsed beverage type in female class 1 (4.26 units, SD 9.55, 3.39 units, SD 22.36 respectively) (Table 8).

Class 2

Class 2 demonstrated the highest levels of unit consumption for all beverage types beer (22.55 units, SD 90.30), cider (33.28, SD 102.02), alcopops (7.59 units, SD 14.91), wine (23.85 units, SD 140.91) and spirits (45.49 units, SD 136.68) when compared to other female classes. Class 2 consumed higher levels of spirit consumption, which had the lowest probability of endorsement in the latent class analysis, compared to other beverage types; this was followed by lower consumption levels of wine, cider, beer and alcopops (Table 8).

Class 3

Cider was the most consumed beverage type in class 3, but the lowest overall when compared to the other classes (18.45 units, SD 100.99). The next consumed beverage type was beer (16.51 units, SD 135.33), followed by spirits (12.05 units, SD 45.66), wine (8.13 units, SD 41.18) and alcopops (3.88 units, SD 7.93). Class 3 latent class analyses endorsed wine as having the highest probability of consumption in class 3, although when unit consumption was examined, wine had the lowest level of consumption across all female classes. Class 3 demonstrated the lowest levels of all beverage types with the exception of beer across all female classes (Table 8).

All SDs for both males and females were higher than the mean for each beverage type, which indicated that the mean consumption was not a good representation of the sample. As a result, data was transformed using a natural log algorithm. Transformed consumption data was used for all subsequent analyses (Appendix 20-21).

3.5.6 Logistic Regression analyses odd ratios with confidence intervals class 1 through to 3

Key demographic data, harm indicators and drinking outcomes were compared for male and female participants in each of the latent classes (Appendix 18-19). Latent class multinomial logistic regressions were conducted to determine the independent association ($p < 0.05$) between alcohol diagnosis, consequences and experience of negative social events with assigned latent classes based on beverage type consumption in the previous 3 months for male and female classes and are presented below.

3.5.6.1 Males

Class 1

Among class 1 males, beer was the least endorsed beverage type from the previous 3 months and participant's reported the lowest number of units consumed for this beverage type in the previous 30 days. Alcopops had the highest level of endorsement across the male classes but this did not translate to the highest level of unit consumption. Notwithstanding, over three-quarters (76.5%) of the class reporting the initiation of alcohol use before the age of 15 and almost half (44.5%) scoring 3 or more on the AUDIT-C, both the highest totals for these variables across male classes. Total

unit consumption in the previous 28 days was negatively associated with class 1 membership (OR=0.609; 95% CI= 0.388-0.957) (Appendix 22, page 87-89).

Class 2

Male Class 2 participant's reported the highest level of endorsement for cider, and highest level of unit consumption in the past 30 days for this beverage type, however this was not found to be significantly associated. Beer had the highest level of endorsement for the previous 3 months across the classes and was also found to be significantly associated with a higher level of unit consumption for this beverage type.

Class 2 members were also found to be 1.4 times more likely to report having been involved in an accident or injured in the past 12 months as a result of alcohol (Appendix 23, pages 90 - 92).

Class 3

Relative to other classes and with the exception of beer, class 3 demonstrated lower levels of endorsement for all other beverage types.

Class 3 reported the highest unit consumption of beer and alcopops across the male classes; however this was not significantly associated with class 3 membership. Membership of male class 3 was found to be significantly associated with greater levels of wine unit consumption. Class 3 was negatively associated with a late onset (<15 years of age) of alcohol initiation (Appendix 24, pages 93-95).

3.5.6.2 Females

Class 1

Females in class 1 reported the highest level of average consumption for spirits, although this was not found to be significantly associated with class 1 membership. Class 1 membership was found to be significantly associated with greater unit consumption for alcopops.

Participant's of this class were 1.8 times more likely to be aged 10-14 years, while 74.7% of the class reported having consumed alcohol prior to the age of 15 years.

Class 1 were 1.18 times more likely to report 'borderline' problematic pro social behaviours. Class 1 members were negatively associated with having been injured/involved in an accident or having been admitted to hospital as a result of their alcohol use in the past 12 months (Appendix 25, pages 96-98).

Class 2

The smallest of female latent classes (17.6%), 83.93% reported having consumed alcohol before the age of 15 years, over half of which scored a total of 3 or more on the AUDIT-C. Irrespective of the lowest endorsement for alcopops, wine and spirit consumption in the previous 3 months, class 2 reported the highest average unit consumption of all beverage types and was associated with multiple risk indicators. Class 2 participants were significantly associated with an increased risk as a result of drinking alcohol including, 2.4 times more likely to engage in unsafe sexual behaviours, 2.3 times more likely to be admitted to hospital, 2.2 times of being a victim of robbery, 1.9 times more likely to be involved in an accident/injury and physical fights. Class 2 participants also demonstrated an increased risk of a number of drinking outcomes including being 2.9 times more likely to reported being intoxicated in the previous 30 days, 1.7 times more likely to report having ever been intoxicated, 2.6 times more likely

to meet MINIKIDS Abuse diagnostic criteria, 1.9 times more likely to report drinking higher than average unit consumption in the previous 30 days compared to other class members. With regards to behavioural and emotional difficulties Class 2 females were 1.6 times more likely to report problems with pro social behaviours but 2.0 times more likely to report normal relationships with peers (Appendix 26, pages 99-101).

Class 3

A total of 90.4% of class 3 members reported having consumed alcohol before the age of 15 years and half of this class (51.4%) scored 3 or more on the AUDIT-C. Class 3 membership, was found to be negatively associated with Alcopop unit consumption. Class 3 were also 1.8 times more likely to report 'Other Ethnicity' (Black, Chinese, Mixed, Asian, Other) (Appendix 27, pages 102-104).

3.6 Discussion

This study applied latent class analysis to a sample of 1342 10-17 year olds attending Emergency Departments across England, and examined whether typologies could be identified on the basis of beverage type consumption in the previous 3 months. A series of regressions examined associations between beverage type latent classes and demographics, drinking indicators and alcohol related harms.

The majority of the sample (76%) reported having consumed alcohol before the age of 15 years and the mean age of alcohol initiation was 12.88 years (SD 2.19). As anticipated, consumption varied considerably with observed differences across ages and gender. Average unit consumption across the sample in the previous 28 days,

measured by the TLFB was 11.11 units (SD 2.19), and while females consumed higher overall levels of alcohol during the previous 3 months, males reported higher levels of consumption per drinking occasion. Approximately, half of the sample (49.5%) scored a total of 3 or more on the AUDIT-C, which is an indication of increasing, or higher risk drinking.

Applying Latent Class Analysis to indicators of beverage type consumption in the previous 3 months revealed a 3 class latent model to have the best fit to the data in both the males and females.

3.6.1 Males

Fewer males scored 3 or more on the AUDIT when compared to females and similarly, fewer met diagnostic criteria for alcohol abuse and dependence as measured by the MINIKID. Males reported an earlier age of onset for alcohol consumption and a larger proportion reported having been intoxicated in their lifetime.

Multinomial logistic regressions revealed beer to be the most prevalent beverage type consumed in the previous 3 months by males. Males were noted to have very similar latent class profiles, and all beverage types were endorsed at very similar levels across latent classes. This may suggest that males, when compared to females demonstrate less variation in alcohol type consumption. In addition to this seemingly low level of variation, male latent class memberships were observed to have few associations with risk indicators when compared to the females.

Male latent class 2 were noted to have an association with higher average unit consumption for beer and having been involved in an accident and/or injured as a result of their alcohol use in the past 12 months.

Overall, there was considerably less variation in beverage type consumption observed in males, with few risk indicators of alcohol use associated with class membership when compared to females.

3.6.2 Females

Overall, females reported consuming a higher level of alcohol units in the past 3 months when compared to males, although drank less on drinking occasions. A greater number of females scored a total of 3 or more on the AUDIT-C, which indicates hazardous or increased risk drinking behaviours. Similarly, a larger proportion of females met the diagnostic criteria for both alcohol abuse and dependence as measured by the MINIKID. Females reported having initiated alcohol use at an older age when compared to the males, however, this difference was marginal.

Analyses revealed spirits to be the most consumed beverage type across females, while cider, wine and alcopops were noted to have been consumed at higher levels in the previous 3 months when compared to males. In contrast to males, females were observed to demonstrate considerable variation in their beverage type consumption across the latent classes, and revealed a number of associations between beverage type classes, demographics, drinking indicators and alcohol outcomes. This could

suggest that a proportion of females are at an increased risk of a number risk factors associated with alcohol consumption, which may in turn be related to beverage type.

Female latent class 2 drew particular interest in the study, the smallest of the latent classes, demonstrated the highest level of associated risks across several domains of interest including, intoxication, sexual behaviours, injuries/accidents as a result of alcohol consumption and meeting diagnostic criteria for AUD.

Results from this study support the body of research, which has evidenced differences in the variation of alcohol use in males and females, both in terms of quantities, frequencies and beverage types consumed.

Both males and females demonstrated varied drinking repertoires, which reflect the fact that adolescents are more likely to consume more than one type of beverage and that, this in itself may increase that individual's level of risk associated with alcohol consumption.

This study suggests that there may be associations with beverage type consumption, which may contribute, to the associated risks of alcohol use in young people and in turn this may require further investigation at the assessment stage to ensure a true and meaningful clinical understanding of an individual's drinking profile is established. Results from this study may also indicate that this may be more pertinent when examining female alcohol use, due to the apparent greater level of risk associated with beverage type consumption in this group.

3.7 Limitations

This latent class analysis was exploratory in nature and as such, causality cannot be inferred. The interplay of internal and external factors when a young person chooses to consume any type of alcohol represents a series of complex processes which, latent class analysis (or indeed any single analysis), is unable to fully capture. Beverage type was assessed using reports of types of alcohol consumed and this is also one of many possible indicators of beverage choice and consumption (e.g. preferred beverage), which, is likely to only partially reflect the full characterisation of a young drinker.

In addition to this, as with any statistical approach that uses categorical data, recoding of continuous indicators must be completed with care to minimise any loss of information during this process. This unstandardised means of selection and definition of variables, which are subsequently used to formulate drinking profiles and typologies, can make drawing comparisons between studies difficult. Further information constraints are noted in the classification of class membership among participant's, in that although latent classes are formed of those participant's which possess the highest probability of belonging to that class, this is not able to account for the fact that the same individual may also have a (albeit lower) level of membership probability assigned to the other classes however, the latent class model will indicate sole class membership.

3.8 Strengths

Latent Class Analysis is not without its merits and this study was able to demonstrate the application of this statistical approach in the identification and characterisation of adolescent's beverage choices. This supported established evidence of the variation in

beverage type consumption in males and females and may be suggestive of underlying unobserved categorical variables, which could be used to divide a population into 'mutually exclusive and exhaustive' latent classes. Latent class formulations could provide new information about any existing underlying population subgroups.

This method not only identified a small set of underlying subgroups characterised by beverage type consumption, but also adopted a person-centred approach which focused on how individual participants were both similar and different to each other with regards to their own drinking typologies.

The latent classes which were constructed in this study sought to characterise young people's alcohol consumption in the previous 3 months by beverage type, while the additional measures provided a greater level of detail on the individual's drinking behaviour. The simple recall of beverage types consumed in a given time period could provide efficient and effective indications of the 'type', or 'profile' of the young drinker which could be used to prompt further assessment where deemed appropriate.

3.9 Conclusions

While there are several measures of alcohol consumption and heavy drinking which have been validated in adolescent populations, these often lack the fine-grained characterisation of drinking patterns. There is a need to identify distinctive drinking patterns or profiles in adolescents, which considers multivariate indicators, in addition to the more traditional quantity-frequency measures.

Latent class analysis identified underlying subgroups of adolescents characterised by distinct patterns of beverage type. Latent class memberships were associated with varying levels of risk for alcohol related harms.

Males and females presented distinct differences in beverage preference and associated risks, which may be indicative of underlying sub groups, characterised by latent factors such as, beverage type consumed. Analyses revealed small variations in male beverage type consumption in the previous 3 months and limited associated harms when compared to females, this could suggest that any existing subgroups characterised by beverage type may be more relevant in female drinkers. Nevertheless, the identification of subgroups based on beverage type consumption may also be indicative of early drinking preferences and related patterns, which could provide insight into future drinking patterns. As such, health advice and prevention or minimisation of alcohol related harms could be tailored accordingly.

Chapter 4 Characterisation of drinking patterns in adolescents attending accident and emergency departments in England

4.1 Introduction

Alcohol misuse and related harms cost society an estimated £21 billion each year, and £3.5 billion of this is afforded to Emergency Departments (ED). EDs are faced with increasing numbers of attendances, from 12.3 million in 2007-08, to 18.3 million in 2012-13. This increase is not evident in those aged younger than 18 years, with attendances in this group remaining relatively stable over the same period (HSCIC, 2014).

Alcohol misuse and related harms are common factors in ED presentations and can account for around 70% of attendances between midnight and 5am on weekend nights (Drummond et al. 2003). However, while often highlighted as being a key burden on EDs at weekends, those under 18 in reality form a relatively small proportion of alcohol related presentations. These numbers are in fact reducing over time, while older age groups have been seen to increase. Between 2009-10, 12,831 under 18s presented at EDs with alcohol related reasons which, formed 0.6% of the total under 18 attendances. In 2010-11 this was reported to be 12,352 (0.6% of total under 18s) and was followed by a reduction in 2011-12 11,306 (0.5% of total under 18s) (PHE, 2014).

Shanmugavadivel et al. (2014) reported a total of 10,455 attendances by 8,303 young people aged between 13 and 17, and revealed 'injuries' to be the most common reason for attendance (72%), followed by abdominal pain (16%), self-harm (11%), fits/faints/funny turns (10%), breathing difficulties (7%) and intoxication (6%).

Interestingly, adolescent's who report consuming alcohol are also more likely to sustain an injury. What remains unclear are the number of young people presenting at EDs with other ailments, but who may also be misusing alcohol (Patton, 2016).

Research has suggested that these figures highlight a continuing decline in young people's alcohol use and misuse in England, although these figures are subject to demographic variations. Initial findings from the SIPS Junior Research Programme reported that on average, 26% of adolescents presenting to ED, reported having consumed alcohol in the previous 3 months. This included 1% of 10 year olds, with the proportion increasing up to 76% of 17 year olds. Furthermore, researchers also reported that consumption varied considerably across the country, with 14% of adolescent's in London reporting consumption of alcohol in the past 3 months compared to 35% in the North East of England. Public Health England similarly reported national rates of under-18 alcohol related hospital admissions to be 40.1 per 100,000 (2011/12 – 2013/14), while London fell to 26.5 per 100,000 within the same period (PHE, 2015). However, inconsistent recordings of alcohol related attendances often cloud the regional and national picture of under-18 ED alcohol related attendances.

Irrespective of recent indications of declines in adolescent alcohol use, alcohol related presentations to EDs in under 18s equate to a significant case load for emergency health services and is often the front line for alcohol related injuries, providing an opportunity to engage with young people regarding their alcohol use. The Government highlighted this in their Alcohol Strategy (2012), 'Health services have a responsibility to ensure this 'teachable moment' is used to advise young people about their drinking' (Alcohol Strategy, 2012).

Recent data suggests that there has been a decline in adolescent's consuming alcohol, but while fewer may be drinking alcohol, those that do are drinking at higher levels than previously reported. Further trends have indicated larger quantities of alcohol being consumed in single drinking sessions, and increased alcohol consumption in young children (Templeton, 2009).

Research has also highlighted groups of young people who may be particularly vulnerable to alcohol misuse and related harms and who are also more likely to become intoxicated. The UK retains its unenviable position of having one of the highest levels of adolescent's who consume alcohol in Europe (PHE, 2014).

4.1.1 Current Assessments

The latest National Emergency Department Survey of Alcohol Identification and Intervention Activity Report found that while the majority of EDs asked young people about their alcohol use (83.3%), very few (11.6%) did so as a part of their clinical routine (Patton, 2016).

The survey also reported alcohol-screening tools were used by 1 in 7 departments (15%). The AUDIT-C was the most common and increasingly used (53.3%) of those departments that used screening tools in practice, and had been used more frequently since 2011. Use of the Paddington Alcohol Test (PAT) and the Alcohol Use Disorders Identification Test (AUDIT) were both seen to have been utilised less between 2011 and 2015, while the FAST Alcohol Screening Test (FAST) showed a significant decrease during this period (-23.5%) (See table 8).

Measuring Blood Alcohol Levels is also another tool used by EDs in the assessment of alcohol use. The National Emergency Department Survey (2015) reported that this service was reported by 61.5% departments on an 'as required' basis (Patton et al. 2016).

Screen Instrument	2011 (%) N=17	2015 (%) N=15	Change (%)
Paddington Alcohol Test (PAT)	29.4	26.7	-2.7
Fast Alcohol Screening Test (FAST)	23.5	-	-23.5*
Alcohol Use Disorders Test (AUDIT)	17.6	6.7	-10.9
Alcohol Use Disorders Test – Consumption (AUDIT-C)	23.5	53.3	29.8
Other	5.9	13.3	7.4

Table 9: 3rd National Emergency Department Survey of Alcohol Identification and Intervention Activity Report: Alcohol Screening Tools used in routine clinical practice

Screening assessments and interventions in EDs remain varied across the UK and many of the current tools, while validated for use in young people, have been largely developed and standardised on the adult clinical population (Slade et al., 2013). As such, criteria may perform differently across age groups, particularly when developmental, personality and social factors in young people are also considered.

4.1.4 Characterisation

While there are a number of screening and assessment measures of alcohol consumption, which have been validated in young people, these can lack the fine-grained characterisation of drinking patterns evident in this population.

Identification of distinctive alcohol drinking patterns, or profiles in adolescence, which considers multivariate indicators, instead and/or in addition to the more traditional quantity/frequency measures, could enable researchers and clinicians to identify alcohol problems at an early stage in this at risk population group. This in turn could not only provide a better understanding of the early onset of any subsequent 'alcohol induced neuropsychological impairments', but ultimately inform alcohol consumption guidelines and practice to improve outcomes and prevent, or reduce alcohol use and harm, at a time when reversibility of harm may still be possible.

Several studies have examined alcohol use patterns in adolescent's using latent class analyses. The varied outcomes, proposed patterns and lack of consensus on such solutions, highlight the research gap and clinical need to establish a well-characterised and validated multi-dimensional measure of drinking patterns based on empirical research.

There are a limited number of studies which examine latent classes within a UK adolescent population, with the majority of studies reporting on the US (Siegel, 2011; Reboussin, 2006; Chung, 2001; Kramer, 2007), New Zealand (Jackson, 2014; Fergusson, 1995) and Europe, not including the UK (Weisner, 2007; Kuntsche, 2004; Whelan, 2014; Braker, 2013; Tomcikova, 2011), which may reflect different patterns of

alcohol using behaviours pertinent to specific drinking cultures, not generalisable to UK populations.

Studies are often limited to specific adolescent populations; secondary schools (Jackson, 2014; Pilati, 2013; Tomcikova, 2011), colleges (Beseler, 2012) and Clinical (Chung, 2001). Furthermore, a number of studies select participants in the interest of specific risk factors associated with alcohol use (Pilatti, 2013; Kramer, 2007). Further LCA research is needed to better establish the number of latent classes, which might be, expected in particular populations (Kuvaas, 2014).

While there are large health related data sets available to researchers these are often not specific to alcohol use, but may contain more general health related data, of which alcohol may be a component. As such, alcohol related variables are often not refined in terms of data obtained i.e. quantity measures. Multiple methods in measuring consumption levels in this population could mean that latent class groups could alter depending on the method of classifying these variables. Similarly, broad measures of drinking such as binge drinking could result in the combination of frequent drinkers, with those who have a low overall intake with occasional binges. A prominent limitation of many of these studies is the reliance on self-report data, which may be subject to biased reporting (Mackie et al. 2001, Jackson et al. 2014).

4.2 Aim

This study aims to examine and identify metrics of alcohol use embedded within a series of alcohol consumption measures, and will consider whether a latent class structure can adequately represent the heterogeneity in drinking behaviours in this sample of adolescent's attending EDs in England. The study will also seek to describe these latent structures, report on their corresponding prevalence and any associations with outcomes of harm. The aim is that latent class structural analysis and the integration of multiple metrics of alcohol use will enable the development of a full characterisation of drinking patterns, which will reflect increasing severity of alcohol use in adolescents and associations with specific risk indicators.

4.3 Method

5.3.1 Participants

Participants were aged between their 10th and 18th birthdays attending one of the 10 participating Emergency Departments (ED) across England; North East, Yorkshire and Humber and London. Eligibility and exclusion criteria have been previously outlined in chapter 2.

4.3.2 Measures

For the purposes of the current study demographics including age, gender and ethnicity were collected. Participants were asked questions about their alcohol use in the previous 3 months and the consequences associated with its use. Questions included; questions 19-21-22 from the ESPAD Study (ESPAD, 2011) (Hibell et al. 2009), Strengths and Difficulties Questionnaire (SDQ) (Goodman et al. 1999; Muris et

al. 2004), the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al. 1993), Timeline Follow-Back (TLFB) (Sobell et al. 1992), the Mini International Neuropsychiatric Interview for Children and Adolescents (MINIKID) (Sheehan et al. 2010) and the Beverage-Specific Quantity-Frequency (BSQF). The AUDIT-C has been validated in adolescent populations in the ED in the United States (Chung et al. 2000; Kelly 2002) and was used to identify hazardous drinking using a cut-off of 3 in-line with the findings of the SIPS Junior study (Coulton et al. 2016). A trained researcher conducted the Time Line Follow Back (TLFB) interview covering the past 90 days (Sobell et al. 1992). The TLFB has been validated for use in this population (Brown et al. 2000; Donoghue et al. 2004) and involves a retrospective interview to ascertain actual alcohol consumed over a 90-day period, total consumption in standard drinks, percentage of days abstinent, standard drinks per drinking day and days of excessive consumption.

A trained researcher conducts the TLFB, whereas both AUDIT-C and BSQF are self-completed instruments. Diagnosis of alcohol use disorder (AUD) will be derived from the MINIKID alcohol use module to assess age-appropriate DSM-IV criteria.

4.3.3 Statistical Analyses

Using data from the SIPS Junior Research Programme, a number of dichotomous indicators were derived from the measures outlined previously, and were used to formulate a series of latent classes of drinking behaviours. Endorsement profile variables were dichotomised using the mean split (See 2.10.1). Indicators used included; unit consumption and number of drinking days in the past 28 days, as measured by the TLFB, age of onset of drinking, lifetime occasions of intoxication as

captured by the ESPAD, and AUDIT-C total score. All analyses were conducted separately for males and females.

All data was cleaned and prepared for analyses in SPSS Version 22 (SPSS inc. 2013), while Latent Class Analyses and series of regressions were performed in Mplus Version 7.2 (Muthen and Muthen, 2012).

Analyses were conducted for a two-class model which were followed by a series of models, with increasing number of classes in each up to a total of 5, to find a model that provided the best level of fit to the data. Each model sought to create empirically derived classes formulated by a series of distinct drinking indicators, which could adequately represent the heterogeneity in drinking behaviours among this cohort of young drinkers.

Each model was subsequently evaluated by a number of model fit indices and comparisons using information criterion to determine the best-fit class model. Models were evaluated in terms of how well individual class membership could be predicted, in addition to how well classes could be distinguished from each other. As previously outlined, models with lower values are preferred and information criteria used to aid model selection included; Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Chi-Square (χ^2), degrees of freedom and entropy.

Analyses aimed to establish a set of distinctive homogeneous classes whereby, differences are assumed to be a result of random measurement error (McCutcheon et al. 1987; Magidson and Vermunt, 2000), and that co-occurrence of latent class membership, associated harm indicators and outcomes of harm are evidence of an underlying class structure within the data set.

Once the model with best fit to the data was identified, a series of regressions were used to examine the associations between the identified latent classes and potential determinants including, demographics, harm indicators, drinking outcomes and beverage preferences as examined in chapter 3.

4.4 Results

Descriptive statistics have been reported on the research sample in the previous chapter (please see section 3.5).

4.4.1 Prevalence of and associations between alcohol risk indicators

Binary logistic regressions were conducted to identify whether any associations between the drinking indicators identified for the purpose of this study existed. Associations identified would subsequently contribute towards the full formulation of drinking latent classes.

4.4.1.1 Males

When examining the male sample, unit consumption (TLFB) had the greatest level of association with drinking days in the past 3 months (TLFB) and Positive AUDIT-C scores. AUDIT-C was found to be associated with number of drinking days in the previous 3 months. Lifetime intoxication was found to be negatively associated with AUDIT-C scores and number of drinking days in the past 3 months. Onset was found to be negatively associated with intoxication, while no associations were found with onset, the AUDIT-C and drinking days in the past 3 months (Table 10).

	Unit Consumption (TLFB)	Onset	Intoxication (ESPAD)	AUDIT-C	Drinking Days (TLFB)
Unit Consumption (TLFB)	-	-	-	-	-
Onset	.857 (0.555-1.324)	-	-	-	-
Intoxication (ESPAD)	.190 (.123-.293)	.531 (.306-.921)	-	-	-
AUDIT-C	12.149 (7.001-21.082)	.919 (.633-1.335)	.091 (.050-.167)	-	-
Drinking Days (TLFB)	30.077 (18.168-49.790)	1.149 (.739-1.788)	.344 (.220-.538)	5.590 (3.607-8.663)	-

Table 10: Associations between drinking indicators for males attending EDs in England, Odds Ratios (OR)

4.4.1.2 Females

When examining the female sample there were a number of associations between the drinking indicators these included, unit consumption being associated with all drinking indicators; drinking days in the past 3 months, AUDIT-C, lifetime occasions of intoxication and onset of alcohol use. Onset of alcohol use was also found to be associated with lifetime occasion of intoxication in females. As found in the male sample, AUDIT-C was found to be associated with drinking days in the past 3 months. Interestingly, in contrast to the male sample both AUDIT-C and drinking days in the past 3 months were both found to be associated with lifetime occasions of intoxication (Table 11).

	Unit Consumption (TLFB)	Onset	Intoxication (ESPAD)	AUDIT-C	Drinking Days (TLFB)
Unit Consumption (TLFB)	-	-	-	-	-
Onset	1.668 (1.031-2.698)	-	-	-	-
Intoxication (ESPAD)	7.600 (4.873-11.854)	1.907 (1.303-2.790)	-	-	-
AUDIT-C	9.903 (5.843-16.785)	1.207 (.847-1.733)	5.817 (4.112-8.229)	-	-
Drinking Days (TLFB)	22.015 (13.501-35.898)	1.364 (.884-2.104)	2.988 (2.066-4.322)	4.968 (3.314-7.488)	-

Table 11: Associations between drinking indicators for females attending EDs in England, Odd Ratios (OR) and 95% Confidence Intervals (CI).

4.4.2 Model Selection

Tables 12 and 13 provide an overview of the model fit parameters for 2-5 latent class models for the drinking indicators outlined in adolescent males and females respectively. Models were examined using a number of criteria to identify the latent model with the best fit of the available data.

4.4.2.1 Males

Model fit indices for the male latent class analysis are shown in table 12. The AIC indicated a superior model for a 3-class structure (AIC = 2867.791) compared to the 2-class model (AIC = 2867.791). However, the BIC indicated a better model fit for a 2-class model (BIC = 2930.507) when compared to a 3-class model (BIC = 2944.364). In

addition to these results, entropy results suggested that a 3-class model had a higher level of classification certainty (entropy = 0.948) compared to a 2-class model (entropy = 0.862). Results greater than 0.80 indicate a good level of separation of identified classes when compared to other models. When average latent class probabilities were examined, these revealed greater levels in the 2-class model (Class 1 0.970; Class 2 0.929), when compared to a 3-class model (Class 1 0.810; Class 2 0.957; Class 3 0.991) (Appendix 28).

Both 4 and 5 class models could not be adequately identified with the available data and analyses did not support a single maximum likelihood solution. Examination of both the 2 and 3 class model solutions and evaluation of the model fit indices led to the selection of a 2-class model for male adolescents.

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	2880.960	2930.507	44.184	20	0.862
3	2867.791	2944.364	19.014	14	0.948

Table 12: Model fit indices for male latent class analysis of drinking indicators (SIPS Jr)

4.4.2.2 Females

Model fit indices for the female latent class analysis are shown in table 13. When examining the AIC, this indicated a superior model for a 2 class latent model (AIC = 3066.240) when compared to other models (3 class = 3067.490; 4 class = 3072.410; 5 class = 3082.619). A 2-class model was also found to the better fit of the latent models when the BIC was considered (BIC = 3115.885), when compared to the other classes

(3 class = 3144.214; 4 class = 3176.214; 5 class = 3213.05). Both 4 and 5 class models could not be identified with the available data, and analyses did not support a single maximum likelihood.

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	3066.240	3115.885	24.278	20	0.809
3	3067.490	3144.214	13.528	14	0.837

Table 13: Model fit indices for female latent class analysis of drinking indicators (SIPS Jr)

In addition to the AIC and BIC, Table 13 includes the degrees of freedom and likelihood rating which indicates whether the model being considered is superior to the null model. As demonstrated in the previous study, entropy is also included and is a measurement of classification certainty. The entropy results pointed towards a 3-class model (0.837) when compare to a 2-class model (0.809) when symptom endorsement profiles and average latent class probabilities were considered. In addition to how well the model reflected the classes in the model, the 2-class model was deemed to be the most superior for female adolescents in this dataset (Appendix 29).

Symptom endorsement profiles for the models identified for both male and females (see Figures 5 and 6), when combined with the results of the model indices led to a 2 class model providing the best fit of the available data for male and female adolescents.

4.4.3 Symptom endorsement profiles for 2 class latent model

Figures 5 and 6 provide symptom endorsement probability profiles for the 2 class models for males and females. As seen in the earlier study examining beverage preference in male and female adolescents, on initial examination there appear to be differences between the two groups drinking indicators.

4.4.3.1 Males

Figure 5 shows the drinking indicator endorsement probabilities for male adolescents. Class 1 which contained approximately 1/5 of the total male participants (n 136, 20.4%) and had overall lower prevalence of all drinking indicators; (1.7%), early onset (13.9%), lifetime occasions of intoxication (17.2%), positive AUDIT-C scores (7.3%) and drinking days in the past 28 days (19.5%).

Class 2 contained the largest proportion of male participants (n 531, 79.6%) and had the highest prevalence of all drinking indicators included in the analyses; total unit consumption in the previous 3 months (19.8%), early onset (63.7%), lifetime occasions of intoxication (65.0%), positive AUDIT-C scores (42.4%), and drinking days in the past 28 days (80.5%).

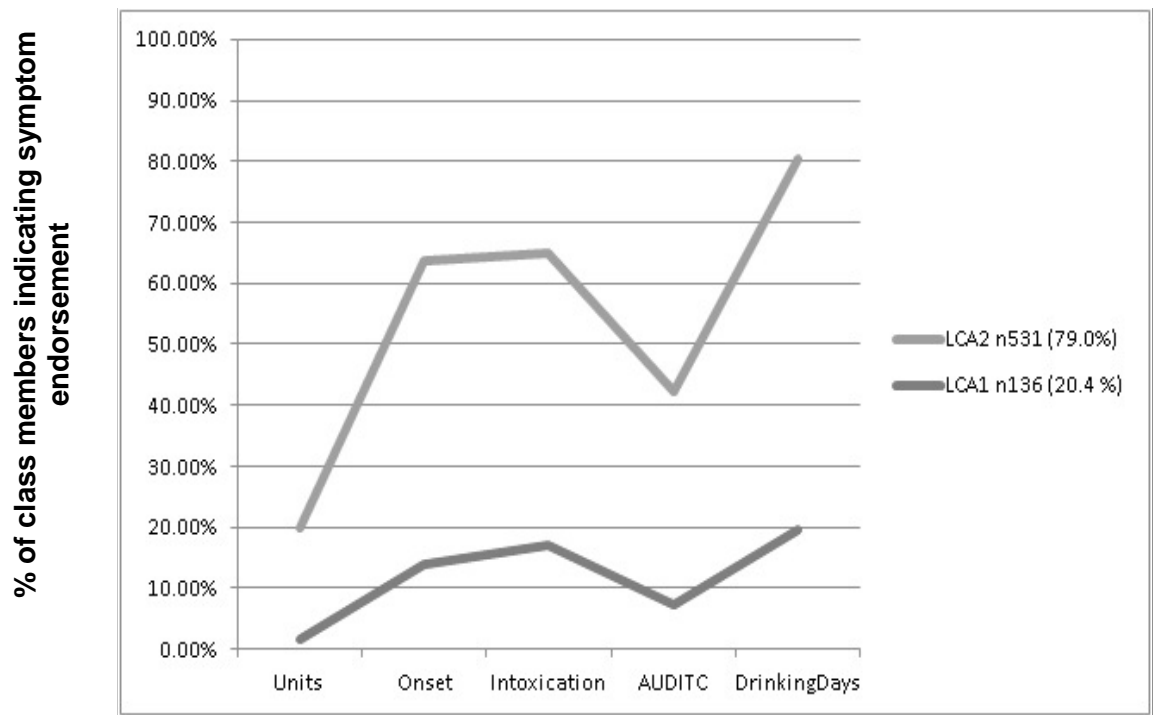


Figure 5: Symptom endorsement profile for 2 class male adolescent drinkers

4.4.3.2 Females

Figure 6 presents the drinking indicator endorsement probabilities for adolescent females. In contrast to the previous study examining beverage preferences in females and the full male drinking indicator latent class analyses, females in this instance, albeit presenting some differences in prevalence of some drinking indicators, also reveal indicators with similar levels of endorsement within each profile. Class 1 contained 28.9% (n 195) of which, 31.3% reported early onset of alcohol use and 42.8% scored positively on the AUDIT-C. Class 1 was characterised by higher levels of endorsement probabilities for units consumed in the previous 28 days (70.5%), lifetime occasions of intoxication (53.5%) and number of drinking days in the previous 28 days (50.3%). Class 2 contained the majority of the female sample (n 479, 71.1%) and was

characterised by the highest level of endorsement probability for early onset of alcohol use (68.7%) and positive AUDIT-C scores (42.8%).

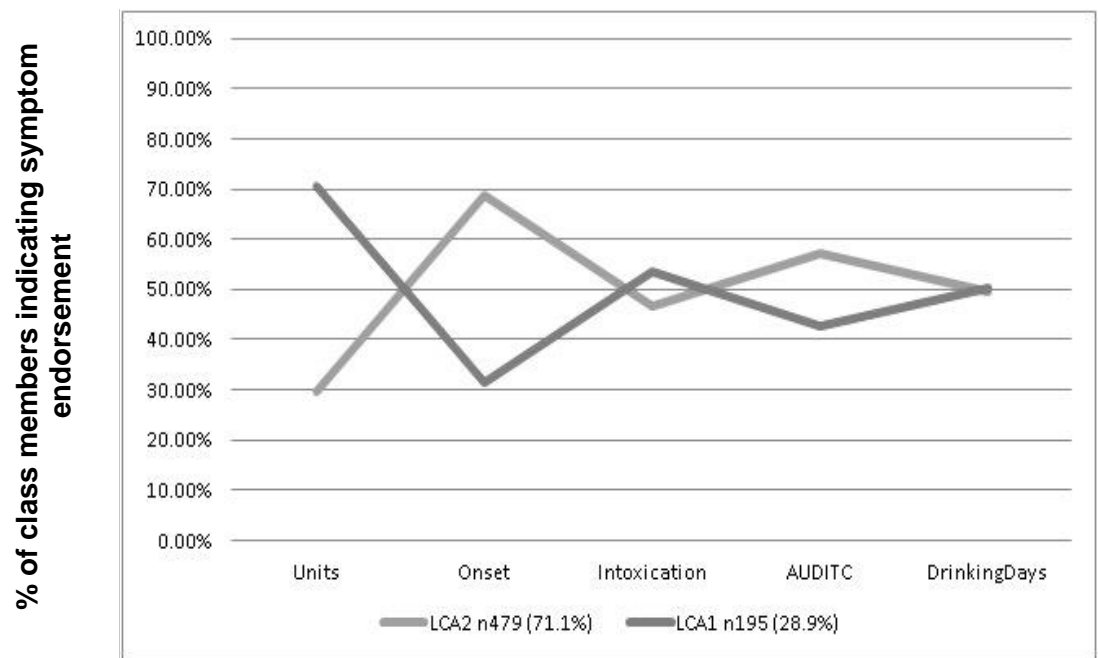


Figure 6: Symptom endorsement profile for 2 class female adolescent drinkers

4.4.4 Latent class profile demographics

4.4.4.1 Males

This study sample included 667 males who had consumed alcohol in the previous 3 months. Class 1, (n 136, 20.4%) were on average 12.80 years old (SD 2.08). The mean age of alcohol initiation for this class was 12.24 years (1.69). A total of 116 (92.1%) reported being of White ethnicity, and 10 (7.9%) reported other ethnicity. A total of 47 (37.6%) of class 1 scored a total of 3 or more on the AUDIT-C, while the mean unit consumption of members from the previous 3 months was 37.79 (SD 43.59) (Appendix 30).

A total of 531 (79.6%) were assigned to class 2, which was the largest of the classes for this latent model examining drinking indicators. The mean age for this class was 12.99 Years (2.16 SD), while the mean age for initiation of alcohol use was 12.43 years (1.76). A total of 439 (86.9%) reported being of white ethnicity, and 66 (13.1%) other ethnicity. A total of 272 (52.7%) scored 3 or more on the AUDIT C, which is an indicator of hazardous drinking, while the mean unit consumption of members from the previous 3 months was 2.205 (5.25) (Appendix 30).

4.4.4.2 Females

Of the 674 females within the sample a total of 195 (28.9%) formed class 1 and the average age of class members was 12.94 (SD 1.68) years old. Class 1 reported on average an earlier age of initiation of alcohol use at 12.52 years (SD 1.66) compared to class 2. A total of 170 (89.9%) of class 1 members reported being of white ethnicity, and 19 (10.1%) from Other Ethnicity. Considerably more class 1 members scored a total of 3 or more on the AUDIT-C (n 136, 72.0%), indicating hazardous alcohol use compared to class 2 females, while the mean unit consumption of members from the previous 3 months was 18.90 (25.74) (Appendix 31).

A total of 479 (71.1%) were assigned to class 2, which, as seen in the male latent class analyses, was the larger of the two classes. The average age of class 2 female was 13.15 (SD 2.07) years old, and mean age of initiation of alcohol use was 12.23 years (SD 1.64). A total of 385 (83.3%) of the class reported being of white ethnicity and 19 (10.1%) of other ethnicity. A total of 182 (39.7%) latent class 2 members scored 3 or more on the AUDIT-C, indicating hazardous use of alcohol, while the mean unit consumption of members from the previous 3 months was 8.00 (24.09) (Appendix 31).

4.4.5 Logistic regression analyses odds ratios

Key demographic data, harm indicators and drinking outcomes were compared for each of the latent classes for both the male and female samples (Appendix 30-31, Pages 107-114).

Logistic, linear and multinomial regression analyses were undertaken to explore the relationship between latent class membership, alcohol diagnostic criteria, psychological and social harms. Unit consumption in the previous 28 days was transformed taking the natural logarithms to ameliorate its non-normal distribution. Table 14 presents significant associations for male and female class 1 members (Class 2 in both samples served as the reference category).

4.4.5.1 Males

Class 1 members formed the smaller of the latent classes (n 136, 20.4%) and reported the highest average unit consumption in the previous 28 days compared to class 2 (27.79, SD 43.59, 2.21, SD 5.25 respectively). The results of the multivariate regression analyses show that male latent class 1 members were significantly associated with positive AUDIT-C scores, indicating hazardous alcohol use (54.53, SD 8.95 – 82.41). Male class 1 members were 3.21 times more likely to report having been intoxicated during their lifetime (Appendix 22, Page 87).

4.4.5.2 Females

Class 1 members formed the smaller of the female latent classes (n 195, 28.9%) and reported the highest average unit consumption in the previous 28 days compared to class 1 (18.90, SD 25.74, 8.00, SD 24.09 respectively). The results of the regression

analysis show that female latent class 1 was associated with an increased risk of a number of health and social problems (Appendix 25, Page 96).

Female class 1 participants were 2.18 times more likely to have consumed alcohol before the age of 14 years. They were 3.67 times more likely to score 3 or more on the AUDIT-C indicating hazardous use of alcohol and 3.65 times more likely to meet MINIKIDS alcohol dependence criteria. Female class 1 members were 6.60 times more likely to report having ever been intoxicated compared to class 2.

Class 1 members were also significantly associated with a number of health and social problems including; being 3.27 times more likely to experience problems with parental relationships, 2.77 times more likely to report an occasion of regretted sexual experience, 2.51 times more likely to report engaging in unsafe sexual behaviours, 2.58 times more likely to have been involved in a physical altercation, 2.42 times more likely to report difficulties at school, 1.99 times more likely to be involved in an accident/injured as a result of having been using alcohol and 1.86 times more likely to be a victim of robbery.

Female class 1 members were 1.82 times more likely to have smoked cigarettes in their lifetime. With regards to behavioural and emotional difficulties they were found to be 1.99 more likely to meet criteria for 'probable' conduct difficulties on the Strength and Difficulties Questionnaire when compared to latent class 2 females (Appendix 26, Page 99).

	Variables	OR	CI	P
Male Class 1 (n=136, 20.4%)	AUDIT-C +ve	54.53	8.95 – 82.41	<.001
	Intoxication	3.21	1.27 – 8.09	.01
Female Class 1 (n=195, 28.9)	Early Onset	2.18	1.35 – 3.53	<.001
	AUDIT-C +ve	3.67	2.39 – 5.64	<.001
	MINIKIDS Dependence	3.65	1.79 – 3.99	<.001
	Intoxication	6.60	4.29 – 10.14	<.001
	Physical Fight	2.58	1.27 – 5.25	.01
	Parent Problems	3.27	1.70 – 6.34	<.001
	School Problems	2.42	1.19 – 4.86	.05
	Victim of Robbery	1.86	1.02 – 3.39	.04
	No Condom	2.51	1.38 – 4.59	.003
	Regretted Sex	2.77	1.34 – 5.71	.01
	Injury	1.99	1.22 – 3.29	.01
	Smoking (ever)	1.82	1.24 – 2.67	.002
	Conduct (Abnormal)	1.99	1.08 – 3.67	.03

Table 14 : Latent class 1 membership and associated measures of alcohol related outcomes of harm in male and females. Reference Category Class 2. (OR Odds Ratios, 95% CI, P = <. 05)

4.5 Discussion

This study applied a latent class analysis to a sample of young people (n 1342) aged between 10 and 17 years attending EDs across England, who reported having consumed alcohol in the previous 3 months. The study examined whether typologies or profiles could be identified on the basis of a limited number of drinking indicators, which adequately represent characteristics pertinent to adolescent alcohol use and misuse.

Approximately half of the total sample (49.5%) scored a total of 3 or more on the AUDIT-C which is an indication of increasing, or higher risk drinking. AUD diagnostic criteria was examined using the MINIKID criteria for both alcohol abuse and dependence and revealed 7.7% and 4.8% of the total sample met this criteria respectively.

A latent class analysis of key alcohol drinking indicators in young people attending ED revealed a 2 class latent model for both male and female alcohol users as having the best fit for the sample data available.

4.5.1 Males

As previously reported males were observed to consume fewer units of alcohol in the previous 3 months when compared to females, but consumed larger quantities of alcohol on occasions when they did drink. While fewer males met the criteria for hazardous drinking as indicated by the AUDIT-C, they did report an earlier age of onset

for alcohol consumption and a larger proportion reported having ever been intoxicated when compared to female participants.

As previously seen with the beverage latent classes in chapter 3, male participants demonstrated less variation in the endorsement of drinking indicators with fewer associations with outcomes of harm when compared to female participants.

Latent class 1 was identified as the higher risk group, due to the elevated average alcohol consumption over the previous 28 days. A series of multivariate analyses revealed limited significant associations with latent class membership including, positive AUDIT-C scores and occasions of intoxication, which may be somewhat anticipated due to the higher level of alcohol consumption compared to class 2.

Higher average levels of alcohol consumption and lower levels of endorsement of drinking indicators may suggest that while class 1 is formed of the higher risk male drinkers, that it is in fact a smaller proportion of this higher risk group which form the very high risk participants.

4.5.2 Females

Females overall, reported higher average unit consumption in the previous 28 days when compared to males. There were also a greater number of females scoring a total of 3 or more on the AUDIT-C, indicating hazardous or increased risk drinking behaviours.

A number of differences were observed between the latent classes, and in particular latent class 1 was highlighted as containing the higher risk female drinkers when

compared to class 2. As seen in the male sample this was the smaller of the two classes and members demonstrated the higher average unit consumption over the previous 28 days when compared to class 2. Latent Class 1 was found to be significantly associated with several alcohol, and other health and social harms including; intoxication, high risk sexual behaviours, injuries/accidents, meeting criteria for AUD and 'probable' conduct difficulties and smoking.

This suggests that male and female adolescent drinkers adopt varying drinking behaviours and patterns, in addition to beverage preference, which may result in differing levels of associated risk. As reported in the previous chapter, which examined preference and associated risks, these results may indicate an apparent heightened risk in some areas of health and social functioning for female adolescents, which warrants further consideration.

4.6 Limitations

Latent class analyses within the scope of this study was exploratory in nature and as such, is unable to establish causality when examining alcohol use and associated behaviours and alcohol related harms. Furthermore, the drinking indicators incorporated within this study are unable to reflect the complexities of alcohol use and misuse in this population. This sample of adolescent's attending EDs in England may present a somewhat unique group of young people with distinctive drinking behaviours and patterns not generalisable to other countries or populations. Limitations are examined in detail in the final discussion chapter.

4.7 Strengths

Latent class analysis was successfully applied to this sample and identified some differences between latent classes for males and females, indicating underlying unobserved categorical variables. A consistency found with the previous study was that when applied to this sample, male and female adolescents' appear to demonstrate varying levels of difference between drinking patterns, behaviours and outcomes of harm.

Never the less, for female and males classes, a series of low and high-risk drinkers were identified drawing from drinking indicators albeit from assessments used in current research and practice, but in a way which provides an alternative method of conceptualising this population with idiosyncratic use of information pertinent to this population. Strengths are examined in detail in the final discussion chapter.

4.8 Conclusion

The number of young people attending EDs with other ailments, but who may also be using and/or misusing alcohol is unclear, but what is known is that those who do use alcohol are more likely to sustain an injury which could result in the individual presenting at the local ED. While young people do not comprise of the majority of ED attenders, the setting itself may, as this study has shown, with a quarter of young people reporting that they have consumed alcohol, provide a rich data source for researchers to examine alcohol use and related harms in adolescent's.

Latent class analysis identified a series of underlying subgroups of adolescent's characterised by a limited number of drinking indicators, considered admissible to this sample and which may be generalisable to a wider adolescent population. These

latent classes were found to be associated with varying levels of risk for alcohol related harms, with distinct differences noted between males and females.

In addition to the distinctive differences observed between males and females, there were also subtle differences observed within latent classes, including smaller proportions of 'higher risk' drinkers reporting what may be considered, 'very high risk' alcohol use in terms of consumption and frequency of use. The characterisation of adolescent's alcohol use is likely to consist of a diverse and complex array of multivariate indicators that existing screening tools and assessments are unlikely to capture. Latent class analysis could provide new information on underlying unobserved variables pertinent to young people who may, or have recently established early patterns of behaviours around the use and/or misuse of alcohol.

Chapter 5 Beverage Preferences in Adolescents: A European Perspective

5.1 Introduction

As seen in the UK, adolescents across Europe are likely to consume more than one type of alcoholic beverage, with observed gender differences in both beverage preference and consumption. While surveys have somewhat broadened our understanding of adolescent beverage type consumption the picture remains unclear. However, the ESPAD surveys, as previously described in chapter 1, have provided comparable data on substance use among 15-16 year olds from 36 European countries, which has enabled some comparisons to be drawn alongside UK adolescents.

European surveys, including the ESPAD, have found beer to be a popular choice of beverage for this population, which accounts for approximately half of adolescent male alcohol consumption, while spirit consumption is the most commonly reported beverage in females. Beer and spirits have been found to account for nearly 70% of total consumption (ESPAD, 2011).

Risks associated with particular beverage types have been outlined in previous chapters and as such will not be repeated here (see 3.1.4.1). What remains evident is that there are a diverse range of motivating factors, which are likely to contribute towards a young person choosing to drink a particular type of alcohol. Furthermore, a European perspective can offer the opportunity to broaden our understanding as to the overall picture of adolescent's alcohol use, and choices being made at a developmentally crucial time. Comparisons drawn between countries could support the

development of a broader understanding as to possible cultural factors influencing beverage type consumption in young people. The identification of subgroups based on beverage type consumption may be indicative of early drinking preferences and related patterns, which could provide insight into possible future drinking patterns and associated risks.

5.2 Aim

This study builds on the previous study in Chapter 3 and applied latent class analysis (LCA) to indicators of beverage choice to examine whether qualitatively distinct subgroups of adolescents from 4 European countries (England, Ireland, Germany, France) could be identified on the basis of their use of different beverage types. Relationships between beverage type latent classes, demographics, harm indicators, drinking outcomes and countries were also examined.

5.3 Methods

5.3.1 Participants

A total of 2000 14-year-old students who attended high school in one of four European countries (England, Ireland, France and Germany) were included in the IMAGEN study. To be eligible for inclusion in the IMAGEN research programme, both participant's and their parents/guardians had to provide consent to taking part in the study. Participants were not eligible for inclusion in the study if they met any of the exclusion criteria outlined previously in chapter 2.

The current study included the data for those participants' who reported that they had consumed alcohol in the previous 3 months (n=1557). A total of 48.04% of the sample were male (n=748) and 51.96% (n=809) were female (Appendix 34).

5.3.2 Measures

Demographics including age, nationality, gender and ethnicity were collected for the purpose of this study. Participants were asked a series of questions about their alcohol use in the previous 30 days. However, in contrast to the previous study (see chapter 3), where participants were asked about the consequences of their alcohol use in the previous 3 months, participants from the IMAGEN study were instead asked about alcohol related outcome expectancies derived from the ESPAD Study Question 21 in addition to questions 17-20 (ESPAD, 2011) (Hibell et al. 2009) (Appendix 4). Participants were also asked questions from the Alcohol Use Disorders Identification Test (AUDIT-C) (Saunders et al., 1993) and the Timeline Follow-Back (TLFB) (Sobell et al. 1992) which captured information on alcohol use over the previous 30 days including, total number of days consuming alcohol and total number of standard drinks consumed.

Beverage type indicators and onset of beverage type use were obtained from the ESPAD questionnaire (ESPAD, 2011) questions 17 and 20 respectively (see 2.11 for list of measures used).

5.4 Statistical Analysis

Using the same approach as demonstrated in Chapter 4, dichotomous indicators of participant's beverage type consumption (beer, cider, alcopops, spirits) for the previous 30 days, derived from the ESPAD questionnaire, were used to formulate latent classes of beverage preference in adolescents. All analyses were conducted separately for males and females.

All data were cleaned and prepared for analyses in SPSS Version 22 (SPSS inc. 2013), while latent class analyses and multinomial regressions were performed in both Mplus Version 7.2 (Muthen and Muthen, 2012) and SPSS Version 22 (SPSS inc. 2013).

As previously demonstrated, analyses were conducted for a two-class model, which were followed by a series of models with increasing number of classes in each, up to a total of 6, to find a model that provided the best fit to the data. Each model sought to create empirically derived classes, or groups of adolescent drinkers based on indicators of beverage type consumed in the previous 30 days.

Each model was subsequently evaluated by a series of model fit indices and comparisons using information criteria to determine the best-fit class model. Models were evaluated in terms of how well individual class membership could be predicted, in addition to how well classes could be distinguished from each other. Models with the lower values are preferred and the information criteria which was used to determine this included, the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Chi-Square (X), Degrees of Freedom and Entropy.

As previously reported, in addition to the model parameters identified in the analyses, consideration is also given as to whether models reflect both meaningful typologies and how readily these profiles can be interpreted. Due to the sample size of this data set it was important that no one class was too small, relative to other classes.

Once the model with best fit to the data was identified, multivariate regression analyses were used to examine associations between latent classes, series of drinking indicators, expectations and outcomes.

5.5 Results

5.5.1 Onset

A total of 2025 participants provided consent to take part in the original IMAGEN research programme. Of these, a total of 1557 (76.9%) male $n = 748$, female $n = 809$, reported that they had consumed alcohol in their lifetime. The mean age of onset of alcohol use for this sample was 12.44 years (SD 1.02), and the mean reported age of first experience of intoxication was 12.70 years (SD 1.09). This suggests that in this sample, once a young person had tried alcohol for the first time, there is a relatively short period of time before their first experience of intoxication.

When onset of different beverage types was examined across the 4 European countries (England, Ireland, Germany and France), it was noted that all countries reported the same order of beverage type use onset. Wine was on average the most likely beverage type to be consumed first (12.46 years, SD 1.06), followed by beer (12.65 years, SD .98), alcopops (12.94 years, SD .92) and spirits (13.14 years, SD

.88). Order of initiation of beverage types was also the same when males and females were examined separately (see table 15).

		Onset M, SD	Onset Intox M, SD	Beer Onset M, SD	Wine Onset M, SD	Alcopops Onset M, SD	Spirits Onset M, SD
Total	Total	12.44 (1.02)	12.70 (1.09)	12.65 (.98)	12.46 (1.06)	12.94 (.92)	13.14 (.88)
	Male	12.42 (1.02)	13.28 (.87)	12.63 (.99)	12.45 (1.07)	12.90 (.96)	13.15 (.91)
	Female	12.47 (1.02)	13.24 (.83)	12.67 (.97)	12.47 (1.06)	12.98 (.89)	13.14 (.84)
England	Total	12.51 (1.04)	12.67 (1.05)	12.68 (1.03)	12.50 (1.11)	12.92 (.90)	13.20 (.81)
	Male	12.47 (1.02)	12.54 (1.11)	12.66 (1.02)	12.56 (1.09)	12.94 (.92)	13.23 (.79)
	Female	12.54 (1.06)	12.83 (.96)	12.69 (1.03)	12.45 (1.14)	12.91 (.89)	13.18 (.82)
Ireland	Total	12.30 (1.00)	12.75 (.99)	12.58 (.98)	12.35 (.99)	13.02 (.86)	13.18 (.89)
	Male	12.42 (1.03)	13.00 (.98)	12.71 (.94)	12.40 (.97)	13.05 (.97)	13.30 (.97)
	Female	12.21 (.98)	12.59 (.99)	12.48 (1.01)	12.31 (1.02)	13.03 (.80)	13.11 (.84)
Germany	Total	12.45 (1.00)	12.71 (1.15)	12.67 (.96)	12.49 (1.04)	12.91 (.93)	13.10 (.91)
	Male	12.42 (1.03)	12.72 (1.19)	12.61 (.98)	12.44 (1.06)	12.80 (.97)	13.07 (.96)
	Female	12.49 (.98)	12.71 (1.15)	12.73 (.92)	12.55 (1.02)	13.00 (.98)	13.03 (.79)
France	Total	12.35 (1.05)	12.62 (1.02)	12.57 (1.01)	12.32 (1.04)	13.03 (.99)	13.14 (.88)
	Male	12.30 (1.02)	12.41 (.98)	12.56 (1.03)	12.33 (1.02)	13.05 (1.01)	13.23 (.94)
	Female	12.41 (1.08)	12.78 (1.03)	12.57 (.98)	12.32 (1.08)	13.00 (.98)	13.03 (.79)

Table 15: IMAGEN study alcohol Use, intoxication and beverage type onset by country and gender, Mean (SD)

5.5.2 Consumption

In the past 12 months a total of 1,746 (86.4%) participants reported having consumed alcohol, while 790 (50.7%) reported having consumed alcohol in the past 30 days. Overall, the sample reported an average of .68 (SD 1.67) days of alcohol use in the previous 30 days.

Around a fifth of participants (21.5%) reported having consumed beer in the previous 30 days (male 23.8%, female 19.3%). Across all countries, a larger proportion of males reported having consumed beer in the previous 30 days compared to females.

Approximately a fifth of participants (21.8%) reported having consumed wine in the previous 30 days (male 17.9%, female 25.5%). Across all countries, a larger proportion of females reported having consumed wine in the previous 30 days compared to males.

A total of 22.1% of participant's reported having consumed alcopops in the previous 30 days. Across all countries it was noted that a larger proportion of females reported having consumed alcopops in the previous 30 days when compared to males.

A total of 21.1% of participants reported having consumed spirits in the previous 30 days. It was noted that these proportions were similar when comparing males and females across the 4 European countries. An exception was found with females from Ireland, who were noted to have both a larger proportion of participant's reporting spirit

consumption (28.8%), compared to males from the Ireland sample (14.8%) in addition to other countries (see Appendix 34).

Higher levels of reporting of having consumed a particular beverage type does not necessarily translate into greater quantities, this will be examined further in later analyses.

5.5.3 Hazardous Alcohol Use

A total of 287 (18.4%) participants scored 3 or more on the Alcohol Use Identification Test (AUDIT-C), which is indicative of hazardous and harmful drinking. There were small variations between positive AUDIT-C scores reported between the countries (England 14.0%, Ireland 18.2%, France 13.4%) but approximately half (49.1%) of Germany's participant's reported positive AUDIT-C scores. A greater proportion of females, compared to males reported positive scores in all countries with the exception of France (see Table 16).

Over a quarter of participants (27.4%) reported having ever been intoxicated by alcohol, with similar levels of reporting being observed across countries and between genders. Of particular note, was the larger proportion of females (61.8%) reporting having ever been intoxicated compared to males (28.1%) in England.

When asked whether participants had been intoxicated over the past 30 days, similar levels were reported across countries and between genders. A total of 9.1% reported having been intoxicated over the past 30 days.

A fifth of participants (21.5%) reported having consumed 5 or more drinks on one occasions in the past 12 months and similar levels were noted across countries and between males and females (See Table 16).

		AUDIT +ve N, %	Intox ever N, %	Intox 30 days N, %	5+ drinks per drinking day
Total	Total	287 (18.4)	425 (27.4)	342 (22.0)	436 (21.5)
	Male	137 (13.8)	241 (24.2)	257 (19.5)	213 (21.4)
	Female	153 (14.9)	258 (24.8)	202 (19.7)	223 (21.7)
England	Total	78 (15.41)	155 (30.63)	149 (29.45)	124 (24.01)
	Male	32 (41.0)	93 (60.0)	98 (65.6)	61 (22.2)
	Female	46 (59.0)	62 (40.0)	53 (58.6)	63 (21.1)
Ireland	Total	34 (18.2)	42 (28.6)	33 (22.4)	47 (24.5)
	Male	14 (41.2)	13 (64.6)	9 (22.4)	38 (22.7)
	Female	20 (58.8)	65 (63.9)	24 (60.5)	27 (26.0)
Germany	Total	141 (49.1)	216 (27.5)	169 (21.5)	205 (20.4)
	Male	68 (48.2)	157 (65.4)	87 (62.3)	100 (20.1)
	Female	73 (51.8)	105 (62.2)	82 (59.2)	105 (20.6)
France	Total	34 (13.4)	58 (24.1)	36 (18.8)	78 (23.7)
	Male	21 (61.8)	35 (60.34)	20 (58.1)	32 (23.7)
	Female	13 (38.2)	23 (39.66)	16 (60.7)	28 (23.7)

Table 16: IMAGEN study hazardous alcohol Use indicators, AUDIT-C positive score (3+), occasions of intoxication ever and in the past 30 days, occasions of consuming 5 or more drinks on one occasion.

5.5.4 Beverage Type Consumption Odds Ratios (OR)

Binary logistic regressions were conducted to identify whether any associations between beverage types existed. It was observed that there was a relatively even spread of beverage type consumption reported by participants over the previous 30 days. All beverage types were associated with each of the types examined, however, the highest level of association was found to exist between alcopops and spirits, followed by beer and spirits when compared to other beverage types. Associations between beverage types could contribute to the formulation of drinking typologies in adolescents. Table 17 provides an overview of beverage type associations based on reported beverage types consumed by 14 year olds in the previous 30 days.

	Total	Over the past 30 days did you consume (Yes)	Beer	Wine	Alcopop	Spirits
Beer/Lager	1557	436 (28.3)	-	-	-	-
Wine	1557	441 (28.3)	2.920 (2.306-3.697)	-	-	-
Alcopop	1557	313 (20.1)	5.615 (4.311-7.312)	2.285 (1.765-2.958)	-	-
Spirits	1557	328 (21.1)	6.119 (4.709-7.951)	3.004 (2.330-3.873)	8.009 (6.067-10.572)	-

Table 17: Past 30 day alcohol consumption by beverage types N, (%) and odd ratios (OR; 95% confidence intervals)

5.5.4 Model Selection

Tables 18 – 22 provide an overview of the model fit parameters for 2-4 latent class models for the indicators of beverage type for each country, for males and females. Models were compared in order to select the model with the best fit to the available data (see 2.15 for estimation and model fit criteria).

5.5.4.1 Whole Sample

Model fit indices for the male and female latent class analyses are shown in table 18. For male participants both the AIC and BIC indicated a superior model for a 2 class model (AIC = 2957.93, BIC = 2999.49). Neither class 4 or 5 could be adequately identified with the available data and analyses did not identify a single maximum likelihood solution. A 2 class model also produced the higher entropy scores (0.69) of the models presented however, this is a lower figure than the suggested 0.80 indicator of a good separation of identified cases, when compared to other models. Nevertheless, the model selection combined with the results of the model indices, in addition to how well the model reflected classes led to the selection of a 2-class model for the male whole sample (Appendix 37).

Model fit indices for the female latent class analysis indicated a superior model for a 3-class solution. Class solutions were informed by a lower AIC score and a good level of entropy (0.87), this was also in addition to greater levels of average latent class probabilities demonstrated for a 3-class model when compared to a 2-class model. As demonstrated in the male sample, neither a 4 or 5 class model could be adequately identified with the available data (Appendix 42).

	2 class		3 class		4 class	
	Males	Females	Males	Females	Males	Females
Akaike Information Criterion (AIC)	2957.93	3837.17	2956.12	3833.56	2965.15	3837.40
Bayesian Information Criterion (BIC)	2999.49	3882.06	3020.12	3903.39	3052.88	3932.18
Chi Square	12.78	19.80	0.98	6.19	-	-
Degrees of Freedom	6	8	1	1	-	-
Entropy	0.69	0.75	0.59	0.87	0.61	0.82

Table 18: Model fit indices for whole sample latent class analysis of beverage types (IMAGEN)

5.5.4.2 England

Model fit indices for the male and female latent class analyses are shown in table 19. For male participant's both the AIC and BIC indicated a superior fit for a 2 class solution (AIC = 812.35, BIC = 815.92). The 2-class model also demonstrated the higher level of entropy across the male classes (0.83). These model fit indices, in addition to greater levels of average latent class probabilities led to the selection of a 2 class model for the England male sample (Appendix 38).

Model fit indices for the female latent class model for England indicated a 3 class model as being the superior model whereby, the AIC in combination with the higher entropy score of class 3, in addition to greater levels of average latent class probabilities supported a 3 class model. However, due to the limited sample size

available, a 3-class model resulted in one class being deemed too small (N 22) to apply further analyses, which would be meaningful in this context. As a result of this, a 2-class model was selected (See appendix 43).

	2 class		3 class		4 class	
	Males	Females	Males	Females	Males	Females
Akaike Information Criterion (AIC)	812.35	1266.39	815.92	1263.64	823.86	1268.69
Bayesian Information Criterion (BIC)	842.03	1300.05	862.09	1315.99	886.53	1339.75
Chi Square	8.51	17.69	2.08	4.94	-	-
Degrees of Freedom	6	6	1	1	-	-
Entropy	0.83	0.70	0.79	0.81	0.74	0.78

Table 19: Model fit indices for England sample latent class analysis of beverage types (IMAGEN)

5.5.4.3 Ireland

For male participant's both the AIC and BIC indicated a superior fit for a 2 class model (AIC = 261.18, BIC = 280.18). Neither class 4 or 5 could be adequately identified with the available data and analyses did not support a single maximum likelihood solution. The 2-class model also produced the higher entropy score (0.81) of the male classes. This combined with greater levels of average latent class probabilities indicated a 2-class model solution for the Ireland male sample (Appendix 39).

Model fit indices for the female latent class analysis indicated a superior model for a 3 class solution when examining the lower AIC and BIC scores. However, further examination revealed that while a 3 class solution also produced a higher entropy score (0.98) compared to class 2 (0.92), when class sizes were considered, a 3-class model produced a class which was deemed too small for meaningful further analyses (n 12). As a result of this a 2-class model was adopted for the Ireland female sample (Appendix 44).

	2 class		3 class		4 class	
	Males	Females	Males	Females	Males	Females
Akaike Information Criterion (AIC)	261.18	229.74	269.64	233.88	279.08	242.61
Bayesian Information Criterion (BIC)	280.18	252.92	299.89	269.93	320.39	291.53
Chi Square	2.09	7.71	0.37	1.843	-	-
Degrees of Freedom	6	6	1	1	-	-
Entropy	0.81	0.92	0.77	0.98	0.71	0.97

Table 20 : Model fit indices for Ireland sample latent class analysis of beverage types (IMAGEN)

5.5.4.4 Germany

For male participant's both the AIC and BIC indicated a 2 class model as being superior when compared to other model solutions. Neither a 4 or 5 class model could be adequately identified with the available data. Furthermore, the 2-class solution also produced the higher entropy level when compared to other classes (Table 20). This combined with additional average latent class probabilities supported a 2-class solution for the male Germany sample (Appendix 40).

Similarly, the Germany female sample also revealed lower AIC and BIC scores when compared to other model solutions, and once again neither a 4 or 5 class model could be supported with the available data. Class 2 entropy scores indicated a good level of separation between classes compared to other models. As such, a 2-class model was identified as having the best fit for the available data for the Germany female sample (Appendix 45).

	2 class		3 class		4 class	
	Males	Females	Males	Females	Males	Females
Akaike Information Criterion (AIC)	1531.65	1826.30	1537.96	1833.55	1547.54	1842.25
Bayesian Information Criterion (BIC)	1567.18	1865.03	1593.23	1893.78	1622.55	1924.00
Chi Square	4.11	4.04	0.42	1.29	-	-
Degrees of Freedom	6	6	1	1	-	-
Entropy	0.68	0.81	0.64	0.75	0.61	0.63

Table 21: Model fit indices for Germany sample latent class analysis of beverage types (IMAGEN)

5.5.4.5 France

Model fit indices for the France male latent class analyses are shown in table 22. Both the AIC and BIC indicated a superior model for a 2 class solution when compared to a 3 class solution in addition to a slightly higher level of entropy when compared to other models. This was further supported by greater levels of average latent class probability

demonstrated in the 2-class model when compared to a 3-class model (Appendix 41). Neither a 4 or 5 class model could be adequately identified for this data set.

Model fit indices for the France female latent class analyses are shown in table 22. As demonstrated in the male sample both the AIC and BIC indicated a 2-class model as having the best level of fit for the sample data, with higher levels of entropy also evidenced. As demonstrated in all of the latent analyses a 4 and 5 class solution could not be adequately identified with the available data and did not support a single maximum likelihood solution (Appendix 46).

	2 class		3 class		4 class	
	Males	Females	Males	Females	Males	Females
Akaike Information Criterion (AIC)	376.75	418.70	381.56	426.61	390.73	433.29
Bayesian Information Criterion (BIC)	400.19	444.01	418.03	465.98	440.22	486.73
Chi Square	6.49	5.67	1.30	3.55	-	-
Degrees of Freedom	6	6	1	1	-	0
Entropy	0.73	0.84	0.72	0.89	0.89	0.98

Table 22: Model fit indices for France sample latent class analysis of beverage types (IMAGEN)

5.5.5 Symptom Endorsement Profiles for Latent Class Models

Figures 7 to 16 provide symptom endorsement probability profiles for the 3 class models for both males and females. The symptom endorsement profiles for males and females presented some distinctions between countries, male and females beverage type consumption in the previous 30 days.

5.5.5.1 Whole Sample

Females

Figure 7 presents the symptom endorsement probabilities for female beverage type consumption. As described above, the model fitting process identified a 3-class model as the preferred model for females. Class 1 contained the majority (70.8%) of the female sample and was characterised by lower levels of endorsement of all beverage types in the previous 30 days compared to other classes. Class 2 was the smallest of the female classes (9.6%) and was characterised by all class members reporting spirit consumption in the previous 30 days and overall higher rates of endorsement for all other beverage types, with the exception of beer in which there was no reported consumption by any class member for the previous 30 days. Class 3 was formed of around a fifth of the sample (19.5%) and was characterised by all class members reporting to have consumed beer in the previous 30 days and with the exception of spirits, had the highest level of endorsement for all other beverage types when compared to other classes (Appendix 48).

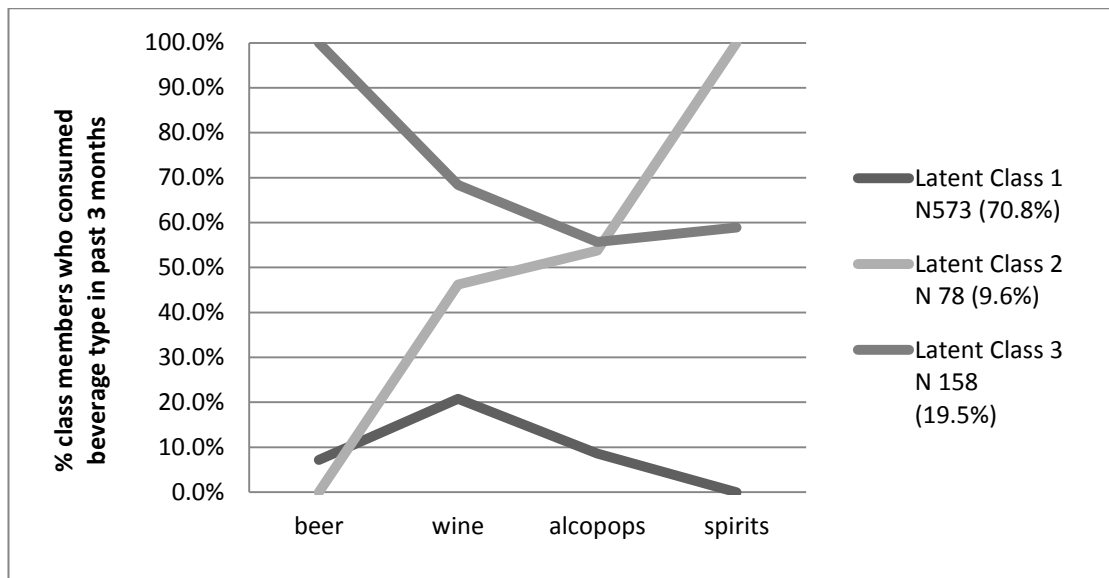


Figure 7: Symptom endorsement profile for female beverage preference latent classes: Whole Sample

Males

Figure 8 presents the endorsement probabilities for males. Class 1 (27.3%), the smaller of the classes had the higher levels of endorsement probabilities for all beverage types when compared to class 2. Individuals in this class had high probabilities (83.8%) of past 30-day beer consumption. Class 2 included the majority of male participants (72.7%) and was characterised by low probabilities of endorsement for all beverage type consumption in the previous 30 days (Appendix 47).

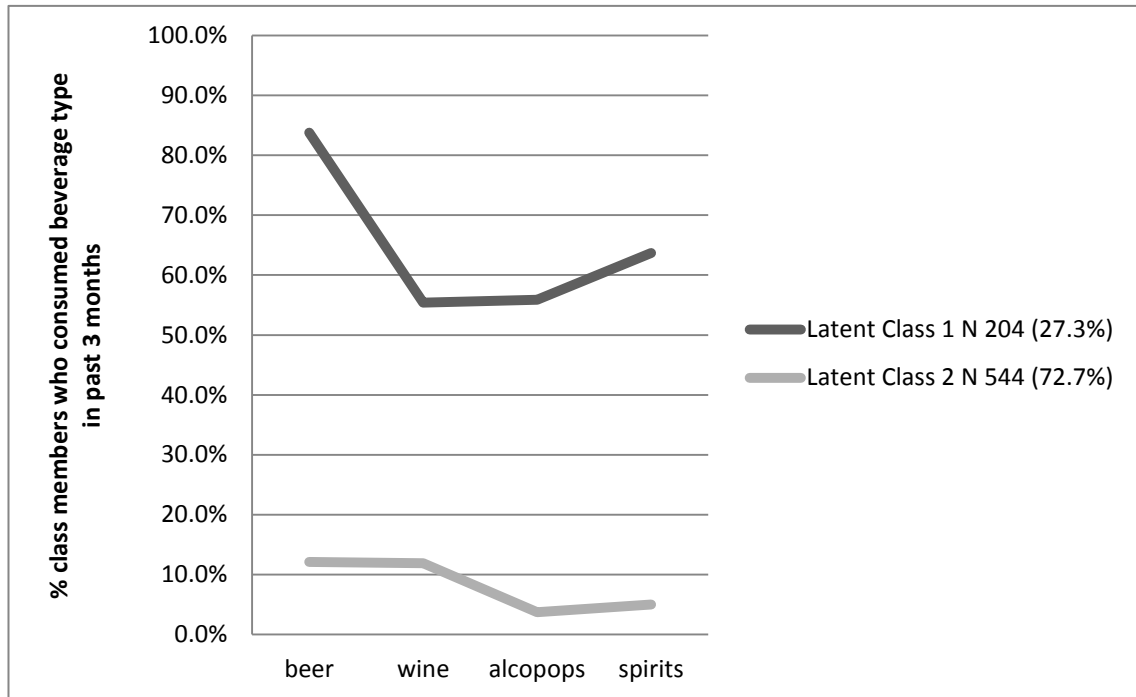


Figure 8: Symptom endorsement profile for male beverage preference latent classes: Whole Sample

5.5.5.2 England

Females

Figure 9 presents the symptom endorsement probabilities for female beverage type consumption. Class 1 formed the smaller proportion of the England female sample (9.5%) with higher levels of endorsement for all beverage types reported in the previous 30 days when compared to class 2. Class 2 contained the majority of the England female participant's (72.4%) and was characterised by the lower levels of endorsements for all beverage types compared to class 1. This class was also characterised by the absence of reported spirit consumption in the previous 30 days (Appendix 50).

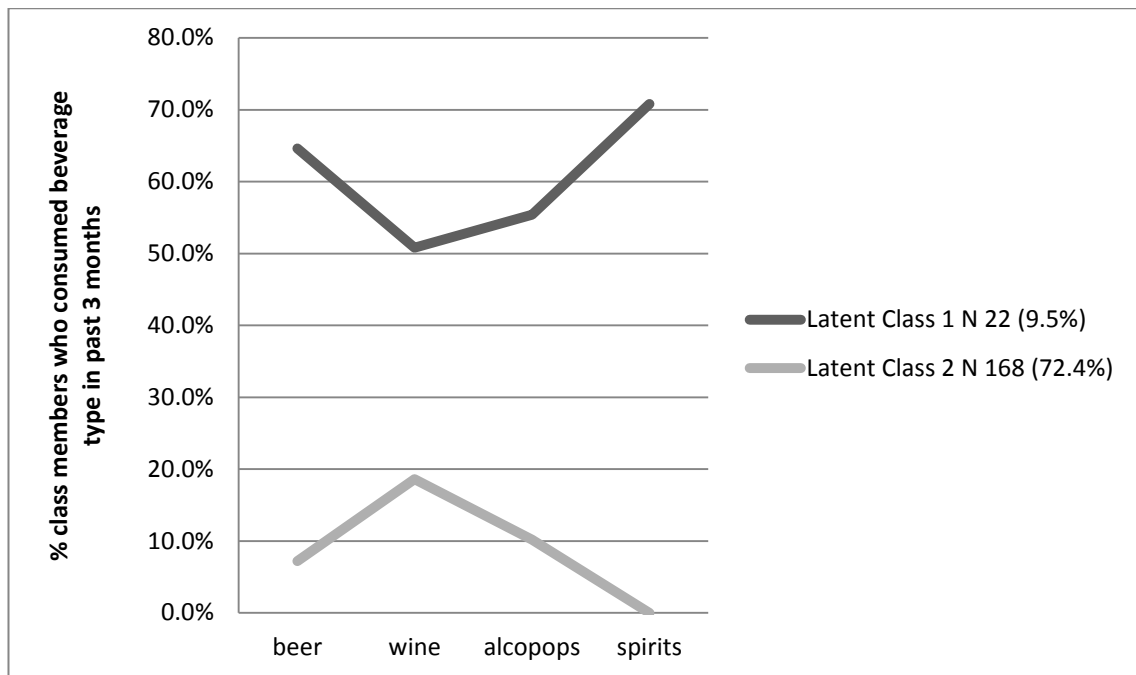


Figure 9: Symptom endorsement profile for female beverage preference latent classes: England

Males

Figure 10 presents the England male sample symptom endorsement probabilities for beverage type consumption in the previous 30 days. Of particular interest was the degree of similarity when compared to the female level of endorsements for beverage types in the same period. As demonstrated in the female sample, in this instance class 1 represented the smaller proportion of the male participants (27.5%) with the higher levels of endorsement for all beverage types in the previous 30 days. Class 2 was formed of the larger proportion of male participant's (72.5%) and was characterised by the lower levels of beverage type endorsement across all beverage types (Appendix 49).

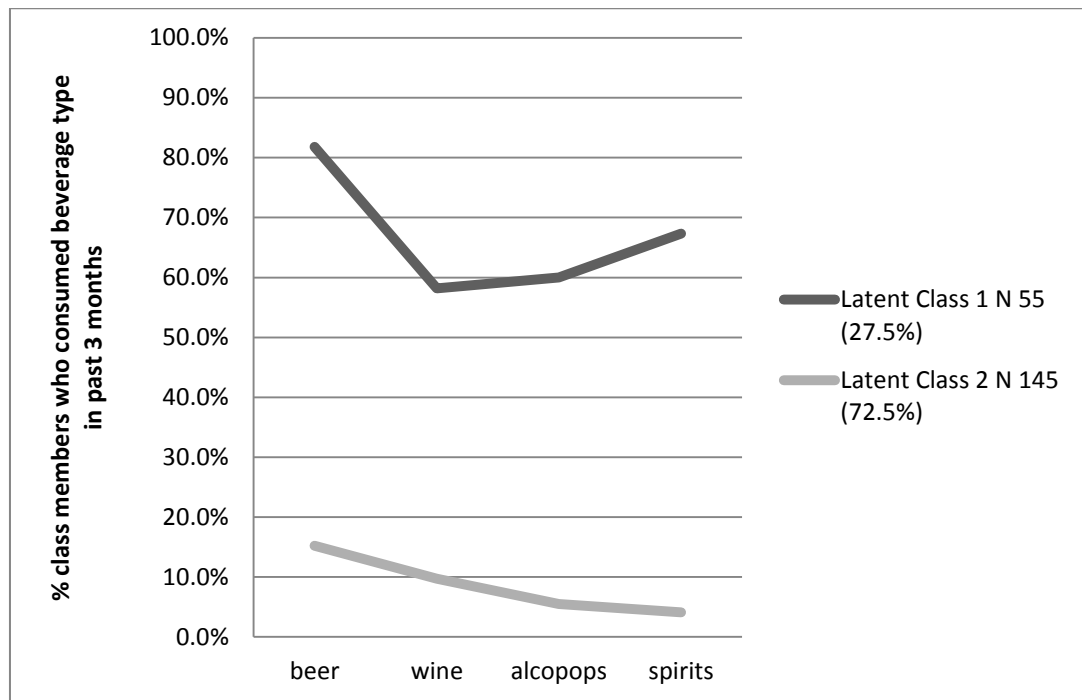


Figure 10: Symptom endorsement profile for male beverage preference latent classes: England

5.5.5.3 Ireland

Females

Figure 11 presents the symptom endorsement probabilities for female beverage type consumption. Classes for the Ireland female sample were more evenly spread when compared to other countries, and classes with approximately half of participant's forming each of the 2 classes. Class 1 (54.9%) presented low levels of beverage type endorsement and no spirit consumption in the previous 30 days. This was in contrast to members of class 2 (45.1%), who reported higher levels of endorsement probabilities for all beverage types consumed in the previous 30 days, with a notable increase for spirits (65.0%)(Appendix 51).

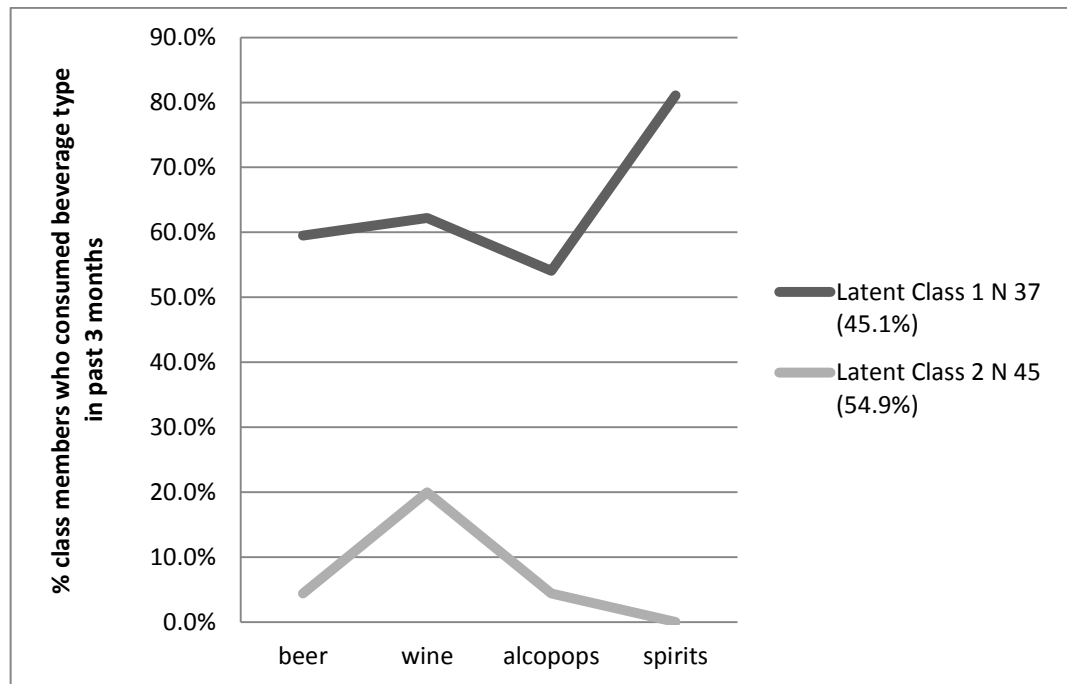


Figure 11: Symptom endorsement profile for female beverage preference latent classes: Ireland

Males

Figure 12 presents the symptom endorsement probabilities for male beverage type consumption, while there are a number of similarities when compared to the female endorsement probabilities there are also some notable distinctions. Class 1 represents the smaller of the male classes (30.8%) and is characterised by all members reporting that they had consumed beer in the previous 30 days. Class 1 also has the higher level of beverage type endorsement for the past 30 days for all beverage types. In contrast to class 1, class 2 which is formed of the majority of the male participant's

reported low levels of endorsement for all beverage types with no spirit consumption in the previous 30 days (Appendix 52).

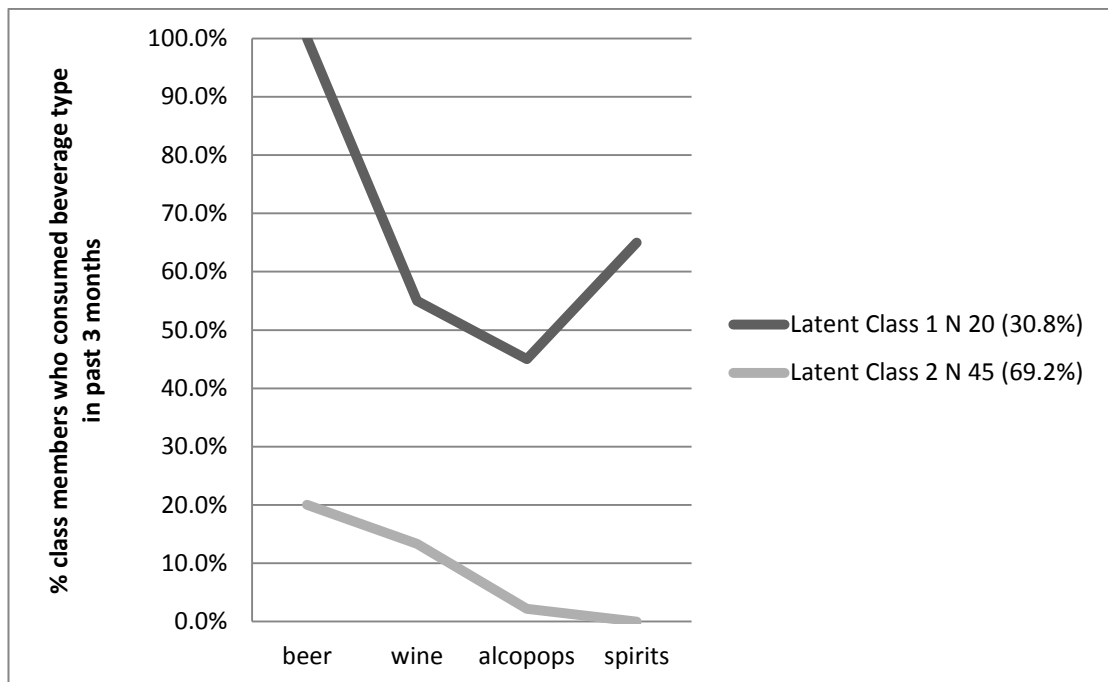


Figure 12: Symptom endorsement profile for male beverage preference latent classes: Ireland

5.5.5.4 Germany

Females

Figure 13 presents the symptom endorsement probabilities for female beverage type consumption. Class 2 forms the smaller latent class (29.2%) and indicates high levels of endorsement for all beverage types. Class 1 is formed of the majority of female participants (70.8%) and is characterised by low levels of beverage type endorsement when compared to class 2. These classes were found to present similar profiles to the male Germany sample (Appendix 53).

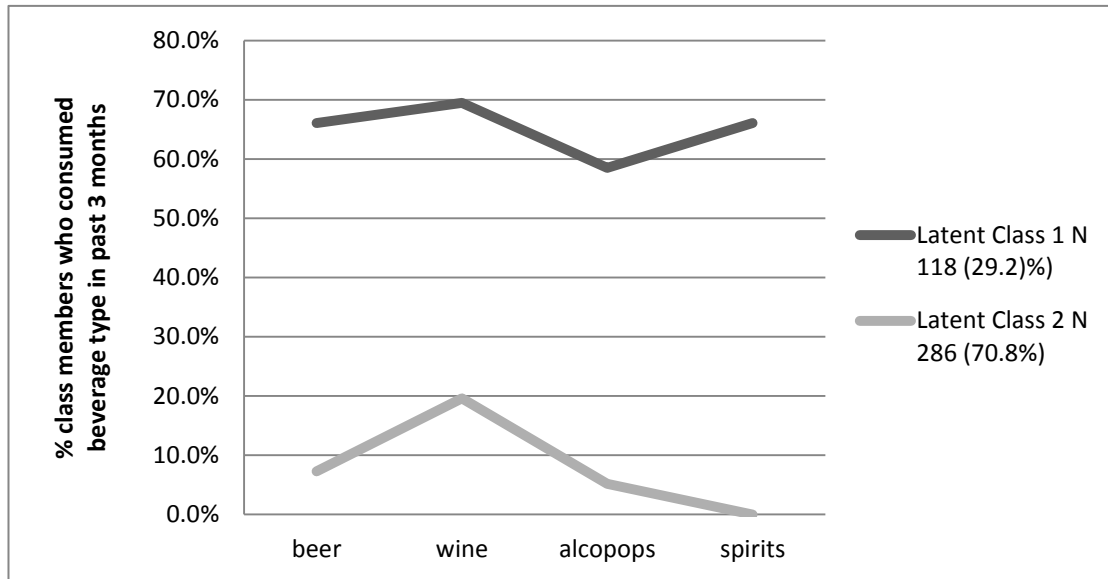


Figure 13: Symptom endorsement profile for male beverage preference latent classes: Germany

Males

Figure 14 presents the endorsement probabilities for males and reveals similar class beverage type endorsement profiles to the female sample. Class 1 forms the smaller of the classes (26.9%), and indicates higher levels of beverage type endorsements, with elevated endorsement levels for beer (81.6%). Class 1 is formed of the majority of male participant's and is characterised by low levels of symptom endorsement for all beverage types (Appendix 54).

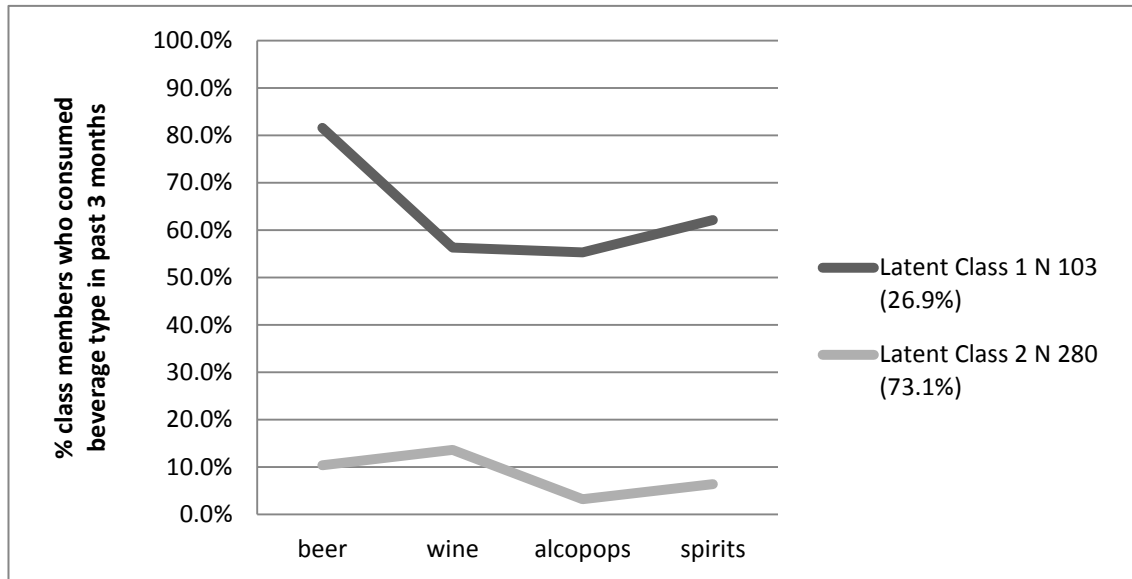


Figure 14: Symptom endorsement profile for male beverage preference latent classes: Germany

5.5.5.5 France

Females

Figure 15 presents the symptom endorsement probabilities for female beverage type consumption for the previous 30 days. Class 1 formed the smaller of the classes (29.7%), and indicated higher levels of all beverage type endorsements for the previous 30 days. Levels of endorsement for each of the beverage types in this class were very similar suggesting that there may not have been particular types preferred over others (beer 59.3%, wine, 59.4%, alcopops 59.3%, spirits 63.0%). Class 2 contained the majority of female participant's (70.3%), characterised by lower levels of endorsement for all beverage types. No class 2 members reported consuming spirits in the previous 30 days (Appendix 56).

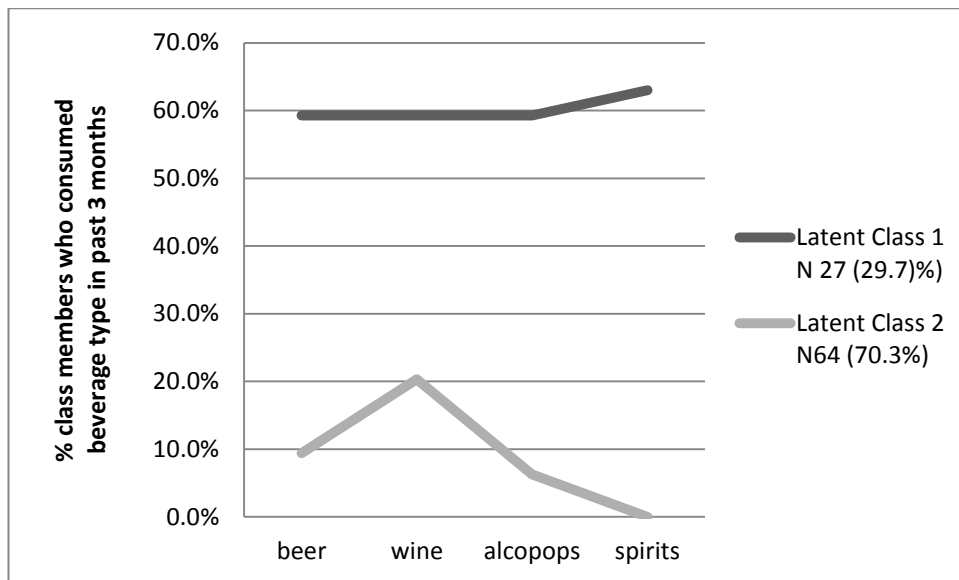


Figure 15: Symptom endorsement profile for female beverage preference latent classes: France

Males

Figure 16 presents the symptom endorsement probabilities for male beverage type consumption. As seen in other profiles, participants formed 2 classes in which class 1 contained a smaller proportion of participant's (26.0%) and demonstrated higher levels of endorsement for all beverage types. Class 1 also had notably higher levels of beer endorsement (84.6%) compared to other beverage types examined. Class 2 contained the majority of male participant's (74%), and was characterised by low levels of endorsement for all beverage types in the past 30 days (Appendix 55).

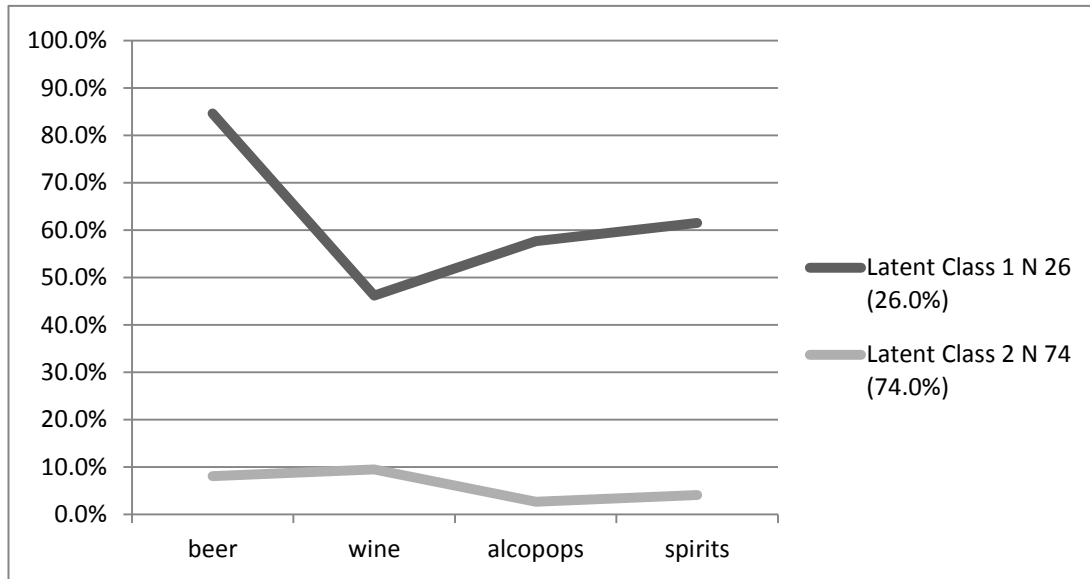


Figure 16: Symptom endorsement profile for male beverage preference latent classes: France

Symptom endorsement profiles for males and females across the countries examined, presented a number of similarities, in addition to some subtle differences in drinking type profiles. Participant's for each country fell into 2 classes, whereby the largest of the classes would reveal the lower levels of beverage type endorsement for the previous 30 days. The smaller classes would reveal higher levels of endorsements with some notable endorsements for certain beverage types including, females in the smaller classes for both England and Ireland revealing higher levels of endorsement for spirit consumption in the previous 30 days compared to other beverage types. In male participant's across different countries within the smaller latent classes, there were distinct increased levels for endorsement for beer over the previous 30 days. Larger classes in all countries examined presented with lower levels of beverage type endorsement, it was also noted that all females in the larger classes reported no spirit consumption in the previous 30 days.

5.5.6 Latent Class Profile Demographics

5.5.6.1 Whole Sample

Males

Latent Class 1 formed the smaller of the 2 classes for the whole sample (n 204, 27.3%). The mean age of onset of alcohol use for this class was 12.29 years (SD 1.06), which was the younger onset of the male classes, while the mean age of first experience of intoxication was 13.39 years. This class also demonstrated higher average AUDIT-C scores (2.73, SD 1.77) compared to the other male classes, and almost half (46.6%) reported scoring 3 or more on the AUDIT-C, indicating hazardous or increased risk drinking behaviours. However, number of standard drinks consumed in the past 30 days was low (1.07, SD 3.61). Class 2 was the largest of the male latent classes (n 544, 72.7%) with a mean onset age of alcohol use of 12.48 (SD 1.00), while the mean age of first experience of intoxication was 13.26 years (SD .86). This class had both lower average AUDIT-C scores (1.31, SD .85) and fewer participant's who indicated hazardous alcohol use on the same measure (40, 7.4%). They also indicated a small amount of alcohol use in the previous 30 days, reporting consuming on average less than 1 standard drink (.98, SD 3.57) (Appendix 59).

Females

Females across the whole sample formed a 3-class solution. Class 1 was formed of the largest proportion of females (n 573, 70.8%) and had the older average age of onset (12.61 years, SD 1.01) compared to other classes. Similarly, this class had the older average age of onset of alcohol use (11.61 years, SD 1.01). In contrast, this

class had the youngest average age of onset of experience of intoxication (11.52 years, SD 1.00). Class 1 had the lowest average AUDIT-C score (1.32, SD .84) compared to other classes and similarly, a lower proportion of class members with AUDIT-C positive scores (n = 49, 8.6%). In contrast to this, class 1 reported a greater average number of standard drinks in the past 30 days (1.11, SD 3.53) when compared to other classes. Class 2 formed the smaller of the classes (n 78, 9.6%), with the youngest average age of alcohol use onset compared to other classes (12.17 years, SD .99). The average age of onset of intoxication was 11.85 years (SD 1.19). Class 2 had an average AUDIT C score of 1.19 (1.34), which indicates lower risk level of drinking behaviours. Participant's on average reported the lowest amount of standard drinks consumed in the previous 30 days compared to the other classes (.85, SD 2.23). Class 3 contained approximately 1/5 of female participant's (n 158, 19.5%), with an average age of onset of 12.20 years (SD .99) and the older age of onset for intoxication across the female classes at 12.10 years (SD 1.28). Interestingly, while this is the older average age of onset for intoxication, it is younger than the whole sample of male onset of intoxication. Class 3 contained the largest proportion of participants scoring 3 or more on the AUDIT-C measure, indicating hazardous drinking behaviours (n 84, 53.2%). In addition to this, participant's also reported the highest average AUDIT-C score across both the female and male whole sample classes (3.03, SD 1.84). Somewhat unsurprisingly, class 3 revealed the, albeit low, larger average number of standard drinks consumed in the previous 30 days (1.15, SD 3.49) (Appendix 60).

5.5.6.2 England

Males

Class 1 was the smaller of the two classes (n 55, 27.5%). This class was characterised by a younger average age of alcohol use onset (12.20 years, SD .96),

onset of intoxication (13.18 years, SD .64) and onset of all beverage type consumption. The average AUDIT-C score was the higher of the 2 classes (2.62, SD 1.84), as was the proportion of participant's scoring 3 or more on the scale indicating hazardous alcohol use (n 22, 40%). In contrast, class 1 was noted to have a lower average standard drink consumption in the previous 30 days (.52, SD 1.24) and similarly, lower average number of days drinking (.49, SD .93) when compared to class 2. Class 2 represented the majority of male participant's (n 145, 72.5%) and was characterised by an average older age of onset (12.55 years, SD 1.04) and intoxication (13.25 years, SD .84). Despite lower average scores on the AUDIT-C measure (1.37, SD 1.13) and a smaller proportion of class members scoring positively on the measure, this class was noted to have the higher average number of both drinking days (.71, SD 1.72) and average standard drink consumption (.94, SD 3.61) (Appendix 59).

Females

Class 1 formed the smaller of the latent classes (n 55, 27.5%) and was characterised by an earlier average age of onset (12.18 years, SD .97) and younger average age of first intoxication (11.94 years, SD 1.22). Class 1 had a higher average AUDIT C score and almost half (47.7%) of the class met the criteria indicating hazardous, or higher risk drinking behaviours. However, this did not translate into higher average consumption of standard drinks in the previous 30 days (0.62, SD 1.67), or total days drinking (0.56, SD 1.41). Class 2 was formed of the majority of the female participant's (n 145, 72.5%) and had a mean age of onset of 12.20 years (SD 1.07). Class 2 members reported an older mean age of first intoxication when compared to class 1 (12.10 years, SD 1.28). Class 2 reported consuming on average 1.23 standard drinks in the previous 30 days, which was the higher reported consumption of the two classes. However, class 2 revealed the lower average AUDIT-C score (1.32 (SD 0.80) and a small proportion met

criteria for hazardous drinking, as indicated by a positive score of the AUDIT C measure.

5.5.6.3 Ireland

Males

Class 1 formed the smaller of the male classes (n 37, 30.8%) with earlier average onsets for both the initiation of alcohol use (12.00 years, SD 0.97) and intoxication (13.20 years, SD 0.84) compared to class 2. Class 1 also indicated increased risk drinking behaviours, evidenced by an average AUDIT C score of 4.55 (SD 3.97) and 16.9% of male participant's reporting positive AUDIT C scores. They also reported higher average standard drink consumption over the previous 30 days (1.37, SD 4.87). Class 2 contained the majority of male participant's (n 45, 69.2%) and revealed both the older average onset of alcohol use (12.67, SD .99) and intoxication (13.50, SD .54) compared to class 2. Class 2 revealed both the lowest average AUDIT-C score (0.96, SD 1.43) and proportion of participant's scoring 3 or more on the same measure (n =3, 4.6%), compared to class 1. Unsurprisingly, class 2 also reported the lowest average standard drink consumption for the previous 30 days (0.72, SD 1.96) (Appendix 59).

Females

Female participant's among the Ireland sample were relatively evenly spread between 2 classes. A total of 37 (45.1%) participants were assigned to class 1 and revealed an older age of onset of 12.44 years (SD 12.44), compared to class 2 but an earlier age of intoxication (13.00 years, SD 0.95). While class members reported consuming less than 1 standard drink in the past 30 days (0.54, SD 1.17), a larger proportion of this class scored 3 or more on the AUDIT-C, indicating hazardous use (n 15, 40.5%).

However, on average class members scored below 3 on this measure (2.49, SD 1.35), this was still a higher average score when compared to class 2. Class 2 (n 45, 54.9%) had a mean age of 12.0 years (SD 0.88) and a later onset of intoxication of 13.18 years (SD 0.73) when compared to class 1. A total of 5 participant's scored 3 or more on the AUDIT C, and the class as a whole had an average score of 1.53 (SD, 1.39). Class members reported on average consuming less than 1 standard drink in the previous 30 days (0.85, SD 2.19) (Appendix 60).

5.5.6.4 Germany

Males

Approximately a quarter (24.5%) of male participants were assigned to class 1, which formed the smaller of the latent classes. The mean onset of alcohol use for this class was 12.44 years (SD 1.09), onset of intoxication was 13.51 years (SD 0.94), both of which were higher on average when compared to class 2. A total of 118 (29.2%) participants scored a total of 3 or more on the AUDIT C, indicating hazardous or increased risk drinking behaviours. However, on average class 1 members scored below 3 on this measure (2.85, SD 1.81). The average number of standard drinks consumed in the previous 30 days was 1.14 (SD, 4.10). Class 2 contained the majority of male participants (n=286, 70.8%) and had an average onset of alcohol use of 12.41 years (SD 1.00) and intoxication of 13.32 years (SD 0.91). A total of 19 (5.0%) class members scored positively on the AUDIT C while the class 2 average for this measure was 1.28 (SD 0.72). The average number of standard drinks consumed in the previous 30 days was 1.07 (SD 3.96) (Appendix 59).

Females

Similarly to the male participants, a total of 87 (21.5%) females formed class 1. Class 1 had an earlier alcohol use onset of 12.18 years (SD 0.92) and intoxication 13.22 years (SD 0.90) compared to class 2 females. Average AUDIT-C scores for class 1 were 2.75 (SD 1.93) and a total of 50 (68.5%) scored a total of 3 or more on the same measure. Class 2 members reported consuming on average 1.22 (SD 3.99) standard drinks in the previous 30 days. Class 2 formed the largest of the classes and contained over 75% of female participants (n 317, 78.5%). The mean age of onset was 12.30 years (SD, 0.97) and intoxication 13.16 years (SD 0.90). Class 2 scored on average lower on the AUDIT-C (1.31, SD 0.81), while a total of 46 participants (11.4%), scored 3 or more on the measure indicating hazardous use of alcohol. Class 2 members reported consuming less than 1 standard drink in the previous 30 days (0.78, SD 2.19) (Appendix 60).

5.5.6.5 France

Males

Approximately a quarter of male participants formed class 1 (n 27, 29.7%), with an average age of onset of 12.12 years (SD 1.17) and onset of intoxication of 13.28 years (SD 0.52). The average AUDIT-C score for class 1 members was 3.0 (SD 2.70), which is the cut off score on this measure indicating possible hazardous alcohol use. A total of 15 (15.0%) class members scored positively on this measure. Class 1 members reported consuming on average 1.33 (0.94, SD 2.91) standard drinks over the previous 30 days. Class 2 contained the majority of participant's (n 64, 70.3%) with an average onset of alcohol use of 12.42 years and onset of intoxication of 12.87 years (SD 0.83), which was the earlier of the classes. A total of 6 class members scored positively on

the AUDIT-C with an average class 2 score of 0.97 (SD 1.32). Class 2 members reported consuming less than 1 standard drink in the previous 30 days (Appendix 59).

Females

Class 1 contained the smaller proportion of female participants (n 27, 29.7%), with an earlier average age of alcohol use onset of 12.08 years (SD 1.13) and intoxication 13.60 years (SD 0.52). The overall average AUDIT-C score for class 2 was 2.15 (SD 1.99), with a total of 6 (6.6%) participants indicating a positive AUDIT C score. Class 1 members reported consuming less than 1 standard drink in the previous 30 days (0.79, SD 1.48). Class 2 females formed the larger of classes (n 64, 70.3%) with a later age of onset compared to class 2 members (12.59, SD 1.02). The mean age of intoxication for this class was 13.38 years (SD 1.04). A total of 7 class members scored a 3 or more on the AUDIT-C indicating hazardous alcohol use, while the average score on this measure for class 2 members was 1.23 (SD 0.62). Class 1 members reported drinking less than 1 standard drinks in the previous 30 days (Appendix 60).

5.5.7 Logistic Regression Analyses Odd Ratios (OR) with Confidence Intervals (CI 95%)

Key demographic data, harm indicators and drinking outcomes were compared for male and female participants in each of the latent classes, between each country (Appendix 61-70, Pages 186-224). A series of multinomial regressions were conducted to determine independent associations ($p < 0.05$) between general health and functioning, cognitive functioning, alcohol use and alcohol-related health and

alcohol expectations and assigned latent class membership based on beverage type consumption in the previous 30 days. Results for both male and females are presented for each of the countries examined and Class 2 served as the reference category.

5.5.7.1 Whole Sample

Males

Class 1 contained the smaller proportion of males for the whole sample and was observed to have higher levels of endorsement for all beverage types consumed in the previous 30 days. Beer was the most prevalently endorsed beverage type for this class. While the age of onset of alcohol use for this class was the younger of the two classes, this was not significantly associated with class 1 membership for male participants. Furthermore, while quantity measures indicated higher levels of unit consumption in the previous 30 days, these were still noted to be low, and not significantly associated with class membership. However, other indicators of hazardous alcohol use were found to be associated with class 1, these included; being 10.94 times more likely to score 3 or more on the AUDIT-C measures, be 5.61 times more likely to report having consumed 5 or more standard drinks on one occasion and 4.17 times more likely to report having consumed 3 or more drinks on the last drinking day reported. No significant associations with either health and social functioning or neuropsychological functioning tasks were found for class 1. A number of positive alcohol expectancies were found to be associated with class 1 membership, this included class members being 2.10 times more likely to report expecting to feel happy, 2.62 times more likely to report feeling more friendly and outgoing and 2.38 times more likely to report that they expected to 'have a lot of fun' if they consumed alcohol (Appendix 61, Page 186).

Females

The whole female sample was formed of 3 classes, which reflected low and high risk drinkers. Class 1 was formed of the majority of female participants, who exhibited lower risk drinking behaviours when compared to other classes. Class 1 members were associated with an older onset of alcohol use and an older onset of intoxication compared to other classes. Analyses did not reveal any statistically significant associations between class 1 and any of the alcohol indicators, harm outcomes, expectations or health and social functioning indicators. Analyses did reveal an association between class 1 membership and correct responses on the pattern recognition task when compared to the other two classes. Class 2 was formed of the smallest proportion of female participants and while they were characterised by a younger age of onset of alcohol use and onset of intoxication, this was not found to be significantly associated with class 2 membership. A number of associations were found with class 2 members including hazardous drinking indicators including, members being 48.58 times more likely to report having consumed 5 or more drinks on 1 or more occasions, 26.21 times more likely to report having consumed 3 or more drinks on the last drinking occasion and 3.85 times more likely to report having been intoxicated on more than one occasion in their lifetime. In addition to these associations with class membership and drinking behaviours, there were also significant associations found with a number of positive expectations of alcohol use, this included, members being 3.81 times more likely to report that they would expect to 'have fun' when drinking alcohol, 3.67 times more likely to report expecting to feel 'happy', 2.56 times more likely to report expecting to 'feel relaxed' and 2.44 times more likely to report expecting to 'forget problems' if they drink alcohol. Class 3 members were found to be associated with the same drinking indicators as found in class 2 albeit at a lower level including, being 25.28 times more likely to report having consumed 5 or

more drinks on one occasion, 8.78 times more likely to have consumed 3 or more drinks on the last drinking day and 2.22 times more likely to have experienced intoxication in their lifetime. What appears to distinguish class 2 and class 3 in females for the whole sample, are both the degree of association with risk indicators, in addition to class 2 being characterised by having all class members reporting they had consumed spirits in the past 30 days and no beer. This was in contrast to class 3 in which all class members reported consuming beer in the past 30 days and no spirits. Class 3 members were also found to be associated with a number of positive expectations of alcohol use including, being 3.37 times more likely to report expecting to 'feel happy', 2.94 times more likely to report expecting to 'have fun', 2.45 times likely to expect being able to 'forget problems' and 2.31 times more likely to report feeling 'more friendly and outgoing' when consuming alcohol. Both Class 2 and 3 revealed negative associations between class membership and correct responses on the pattern recognition task when compared to the other class (Appendix 62, Page 190).

5.5.7.2 England

Males

Class 1 males from the England sample formed the smaller of the 2 classes and while characterised by the younger average age for onset of alcohol use for all beverage types and intoxication, this was not found to be significantly associated with class membership. Similarly, while both positive AUDIT-C scores and average alcohol unit consumption were found to be higher in this class, this too was not found to be significantly associated with membership. The only hazardous drinking indicator to be significantly associated with class 1 membership for this sample was the consumption of 5 or more standard drinks in one drinking occasion, 1 or more times in their lifetime. Class 1 members were found to be 6.95 time more likely to report this than class 2

members. No significant associations with either health and social functioning or neuropsychological functioning tasks were found for class 1 (Appendix 63, Page 195).

Females

Class 1 females from England formed the smaller of the latent classes for this sample, characterised by an overall average earlier age of onset, in addition to almost half of the class scoring 3 or more on the AUDIT-C. Unsurprisingly, this class was 7.96 times more likely to score 3 or more on the AUDIT-C scale when compared to class 2 and also 4.88 times more likely to report having consumed 5 or more drinks on one occasion, 3 or more times in their lifetime. This class was found to be 4.72 times more likely to report that they would expect to 'not be able to stop drinking' compared to class 2 (Appendix 64, Page 200).

5.5.7.3 Ireland

Males

Class 1 males from the Ireland sample were characterised by both earlier average age of onset of alcohol use and onset of intoxication however, neither were found to be significantly associated with class membership. Similarly, while class 1 members were found to have higher average AUDIT-C scores and higher average unit consumption in the previous 30 days, neither were found to be significantly associated with class 1 membership. As seen in the male England sample, the only hazardous drinking indicator to be found significantly associated with class 1 was the consumption of 5 or more drinks on one occasion, 3 or more times in their lifetime. Class 1 members were 32.53 times more likely to report this. While no significant associations were found with either health and social functioning or neuropsychological functioning tasks, class 1

members were 2.41 times more likely to report that they would expect to 'feel relaxed' if they consumed alcohol (Appendix 65).

Females

While consisting of similar sized latent classes, class 1 was formed of a smaller proportion of participants and characterised by an older age of onset of alcohol use but younger average age of onset of intoxication. Class 1 members were associated with a number of hazardous drinking indicators when compared to class 2. Members were found to be 16.95 times more likely to report having consumed 3 or more drinks on the last drinking day, 9.12 times more likely to report having consumed 5 or more drinks on one occasion, 3 or more times in their lifetime and 1.62 more likely to score a total of 3 or more on the AUDIT-C. While no significant associations were found with both health and social functioning or neuropsychological functioning tasks, class 1 members were found to be 5.46 times more likely to report expecting to 'not be able to stop drinking' (Appendix 66, Page 190).

5.5.7.4 Germany

Males

In contrast to other male classes, Germany Male class 1 revealed older average age of onset of alcohol use. However, this was not significantly associated with class membership. Class 1 membership demonstrated a very small association with positive AUDIT-C scores. Greater levels of association were found in hazardous drinking indicators, which included class 1 members being 6.09 times more likely to report having consumed 5 or more standard drinks on one occasion more than 3 times in their

lifetime and 5.08 times more likely to report having consumed 3 or more drinks on their last drinking day. As seen in the male class 1 for the Ireland sample, class 1 members were 1.71 times more likely to report expecting to feel relaxed if they consumed alcohol. A marginal association (OR .01, CI .00 - .03) was found for the number of negative total omissions in the Affective Go-No-Go Task (AGN) (Appendix 67, Page 200).

Females

Class 1 formed the smaller of the Germany female latent classes and was characterised by an earlier average age of onset and first experience of intoxication when compared to class 2. Over half of the class scored a total of 3 or more on the AUDIT C and class 1 members were 5.86 times more likely to score positively when compared to class 2 members. In addition, class 1 members were 3.14 times more likely to report having consumed 5 or more drinks on one occasion, on 3 or more times during their lifetime and 6.09 times more likely to report having consumed 3 or more drinks on the last drinking day. While no associations between neuropsychological functioning and class membership were found, class 1 members were 3.55 times more likely to report expecting to 'get into trouble with the police' and 3.89 times more likely to report expecting to 'not be able to stop drinking' (Appendix 68, Page 200).

5.5.7.5 France

Males

Class 1, as seen in the other male samples was formed of the smaller proportion of male participants. Class 1 was characterised by a higher average AUDIT-C score when compared to class 2, and this was found to be significantly associated with class

1 membership as participants were found to be marginally more likely to score 3 or more on this measure (OR .08, CI .01 – 1.01). No other drinking indicators, health and social or neuropsychological functioning measures were found to be associated with class 1 membership. As found in the Ireland and Germany male samples, class 1 members were found to be associated with reporting expecting to ‘feel relaxed’ if they consumed alcohol (Appendix 69, Page 205).

Females

Class 1 was the smaller of the latent classes for females in the France sample, characterised by an average earlier age of onset and first experience of intoxication when compared to class 2. While there were no significant associations found between health and social functioning indicators, there were associations found between class membership and positive expectations of alcohol use including, participants being 3.74 times more likely to expect feeling ‘more friendly and outgoing’, 7.56 times more likely to report expecting to ‘have a lot of fun’ and 2.09 time more likely to report being ‘able to forget problems’ when consuming alcohol. There was a marginal increased association with class 1 membership an the Affective Go No Go task (Appendix 70, Page 210).

5.6 Discussion

This study applied latent class analysis to a sample (n 1557) of young people (14 years) from 4 European Countries (England, Ireland, Germany and France), and examined whether drinking typologies could be identified on the basis of beverage type consumption in the previous 30 days. Comparisons were drawn between male and female participants and between different countries. Considerations were also made

as to whether the previous study of beverage type preference, using a latent class analysis on a sample of young people attending ED across England, revealed any consistencies with models constructed with a second sample of adolescents.

Although this study examined alcohol use in 14 year olds there were some striking similarities between these outcomes and the ESPAD (2011) results, which examined alcohol use in 15-16 year olds. The ESPAD survey reported that 70% of 15-16 year old surveyed reporting having consumed alcohol in their lifetime. In this study, a total of 76.6% reported having ever consumed alcohol and similarly to the ESPAD survey, just over half (50.7%) reported consuming in the past 30 days. With regards to age of onset results, this study revealed the average age of first consumption to be 12.44 years, which again mirrors the finding that 75% of ESPAD participant's reported consuming alcohol on or before the age of 13. Onset ages between males and females were found to be very similar in this study, which is in contrast to the ESPAD finding that males were more likely to report earlier age of first consumption.

When beverage type consumption was examined, it was found that in this sample of 14 year olds the reporting of beverage type consumption was relatively evenly spread among the different drink types. The ESPAD survey revealed beer to be twice as likely to be reported as having been consumed when compared to spirits. This could suggest that by the age of 15-16 adolescents are (or beginning) to consume certain beverage types over others. This in turn could indicate that beverage preferences may not have emerged at earlier ages, which may limit how much this drinking indicator can inform our understanding of drinking typologies in young people.

Over a quarter of participant's reported having ever been intoxicated (27.4%), and similar levels were observed for both male, females and between countries. However, in line with previous research this study found that the proportion of girls reporting having ever been intoxicated in England was considerably larger when compared to other countries.

With the exception of the female whole sample, all countries examined individually produced 2 class models as having the best level of fit. Analyses of data from each individual country identified one smaller class, which demonstrated earlier onset and larger proportions of positive AUDIT-C scores when compared to the second larger class. The exception to this was females in the Germany sample, in which the larger of the two classes produced the larger proportion of AUDIT-C positive scores and did not have the earlier onset of the 2 classes.

Overall, consumption and drinking indicators revealed similar levels between male and female participants in this sample. There were some marginal differences noted, including males reporting consuming more drinks per drinking occasion, and larger proportions of participant's meeting AUDIT-C positive criteria when compared to females, but differences were small and offered limited opportunity for meaningful interpretation. While no health and social functioning or neuropsychological functioning indicators were associated with membership of a particular latent class, male latent classes analyses revealed associations with positive expectations of alcohol use, while no negative expectations were revealed as being associated with classes.

Similar outcomes were revealed among female participant's, and of particular interest was that over a half of both the England and Ireland female sample reported positive

AUDIT-C scores, the largest proportions across the sample of both females and males. Class 1 females across all samples, with the exception of France, were more likely to report having engaged in hazardous drinking behaviours including, consuming 3 or more drinks on their last drinking day and consuming 5 or more standard drinks on 3 or more occasions in their lifetime. Three of the four countries examined revealed females in class 1 to be more likely to expect 'not being able to stop drinking'.

Although some differences in two cognitive tasks were noted in the Germany male, Whole and France samples for females these were marginal, and with regards to the impact on neuropsychological functioning, these differences are likely to have minimal impact on the daily functioning of participants

Overall, there was less variation in beverage type consumption observed in male participants when compared to females. These results support previous research, which suggest distinctions in alcohol preference and use in males and females exist and that adolescents are likely to consume more than one type of beverage.

5.7 Limitations

Limitations of LCA have previously been outlined (see 3.6.3) and are expanded upon in the discussion chapter. Beverage type as a risk indicator for problems associated with adolescent alcohol use and misuse is one of a multitude of influencing factors, and is unlikely to adequately reflect the complexities of the drinking typologies found in young people.

5.8 Strengths

Latent Class Analysis was successfully applied to this European sample of 14-year-old drinkers and was found to support evidence of existing underlying categorical variables used to divide a population into 'mutually exclusive and exhaustive' latent classes. This information could provide and/or support new information around existing underlying population groups of young drinkers.

The focus on how individuals within the sample are both similar, and different to each other using the simple recall of beverage types consumed in the past 30 days could provide efficient and effective means of identifying drinking typologies. This could prompt further assessment in an efficient and appropriate way. Strengths of this study are expanded upon in the discussion chapter.

5.9 Conclusions

Building on the previous studies (see chapter 3-4), these series of analyses sought to examine whether qualitatively distinct subgroups of young people from across four European countries could be identified on the basis of their use of different beverage type use and considered associations of harm indicators.

Examination of the data supports previous research, which suggests that adolescent's are more likely to consume more than one type of alcoholic beverage, and be more likely to experience the harms related to alcohol use from a given volume of alcohol when compared to other age groups. In addition to consuming more than one type of beverage, participants across the sample were observed to demonstrate the same

order of initiation for each of the beverage types examined. Participant's also revealed a similar average age of onset of alcohol use, often with a relatively short period of time before individual's first experience of intoxication. The onset of alcohol use in young people may present an important point in which the timely delivery of health education could result in the reduced likelihood, or postponement of the first occasion of intoxication.

The differing proportions of reported beverage type consumption in 15-16 year olds in the ESPAD (2011) could indicate the emergence of preference for particular beverage types over others in this population. In contrast to this, this study found similar proportions of beverage types being reported. This could suggest that beverage preference had yet to emerge in this younger sample, and subsequently may not be indicative of particular drinking typologies or profiles in this, or younger age groups.

Females revealed a greater number of associations between beverage type classes, drinking indicators and alcohol outcomes when compared to males. This aspect of the study goes some way to support the notion that a proportion of females may be vulnerable to an increased number of risk factors associated with hazardous alcohol consumption when compared to males. In addition to this, the types of beverage consumed may have a greater influence in the formulation of drinking typologies in female populations, which could be suggestive of a greater level of risk associated with beverage type consumption in this group.

Chapter 6: Characterisation of drinking patterns in 14 year olds and the impact of alcohol use on Neuropsychological functioning: A European Perspective

6.1 Introduction

Despite 14.7% of the world's population forming the WHO European region, over a quarter of the world's alcohol consumption is accounted for by these member states (WHO, 2014). While data on young people's drinking behaviours is increasing, this is often limited to those aged 15 years and older. This results in a considerable paucity of information and studies on younger populations, and while recent trends suggest that there may be fewer young people consuming alcohol, it is becoming increasingly apparent in those that do, are consuming larger amounts of alcohol than previously reported (DoH, 2007; IAS, 2013).

The ESPAD (2011) survey reported that just over half of all participants from across 40 European countries reported drinking alcohol before the age of 13 (Fuller et al. 2013). Early onset of alcohol use has been associated with longer-term alcohol related problems (WHO, 2012), and as such, capturing data on younger people is of importance if research is to establish the early markers associated with neuropsychological development in young people who use alcohol.

Research has established a clear relationship with a range of neuropsychological function domains impacted by chronic alcohol use in adults including; Visio-spatial, executive functioning, attention and working memory with a number of these drawing

some similarities to those found in younger chronic alcohol users (Yucel et al. 2007; Harper, 2009). It remains unclear as to the impact of the age of onset of use and consumption has in this younger population when examining neuropsychological function. This ambiguity is compounded further as initiation of alcohol use during adolescence is at a time of complex, neurological development, which is equally abounded with large gaps in scientific understanding.

While advances in neuroimaging techniques have enabled researchers to demonstrate the functional and structural changes in the adolescent brain, and cognitive assessments can indicate cognitive functions that have been found to correlate with brain constructs, there remains a large gap of understanding in this developmentally rich period. Furthermore, while a young person may be in the early stages of exploring and initiating alcohol use, any impacts from this substance are unlikely to have established themselves to manifest in differences.

Advancing research and understanding in the neuropsychological development in adolescents, while simultaneously capturing alcohol-using behaviours in a younger population could provide a better understanding of the early onset of 'alcohol induced neuropsychological impairments'. Information obtained could be used to prevent or reduce alcohol use and harm in this population, when reversibility of harm may still be possible.

6.2 Aim

This study aims to examine metrics of alcohol use, which are embedded within a series of alcohol consumption measures, which have been previously outlined in Chapter 5, and consider whether a latent class structure could adequately represent the

heterogeneity in drinking behaviours in this European sample of 14-year-old students. The study will describe any existing latent structures, reporting on prevalence and associated outcomes of harm where present. Associations between latent classes characterising drinking behaviours and neuropsychological function tasks will be examined. The aim is that latent class structural analysis and the integration of multiple metrics of alcohol use will enable the development of a full characterisation of drinking patterns, which represent key characteristics of alcohol use and/or misuse in young people.

6.3 Methods

6.3.1 Participants

A total of 2025 14-year-old students who attended a high school in one of four European countries (England, Ireland, France and Germany), were included in the IMAGEN study. To be eligible for inclusion in the IMAGEN research programme, both participant's and their parents/guardians had to provide consent to taking part in the study. Participant's were not eligible for inclusion in the study if they met any of the exclusion criteria previously outlined in chapter 2, and included the data for those participants who reported that they had consumed alcohol in the previous 30 days (n=1557) as outlined in Chapter 5.

6.3.2 Measures

Demographics including age, nationality, gender and ethnicity were collected for the purpose of this study. Participant's were asked a series of questions about their alcohol use in the previous 30 days, which have been previously outlined in Chapter 2 (see 3.7-3.8).

6.4 Statistical Analyses

Using data from the IMAGEN research programme, a number of dichotomous indicators were derived from measures previously outlined in Chapter 2. Endorsement profile variables were dichotomised using the mean split (See 2.10.1). These indicators were used to formulate a series of latent classes of drinking behaviours. As outlined in Chapter 2, indicators used included, unit consumption, number of drinking days in the past 30, as measured by the TLFB, age of onset of drinking, lifetime occasions of intoxication, as captured by the ESPAD and AUDIT-C total score. All analyses were conducted separately for males and females.

All data was cleaned and prepared for analyses in SPSS Version 22 (SPSS inc. 2013), while latent class analyses and series of regressions were performed in Mplus Version 7.2 (Muthen and Muthen, 2012).

Analyses were conducted for a two class model, followed by a series of models with increasing number of classes in each, up to a total of 4, to find a model that provided the best level of fit to the data. Each model sought to create empirically derived classes formulated by a series of distinct drinking indicators, which could adequately represent the heterogeneity in drinking behaviours among this cohort of 14-year-old students.

Each model was subsequently evaluated by a number of model fit indices and comparisons using information criterion to determine the best-fit class model. Models were evaluated in terms of how well individual class membership could be predicted, in

addition to how well classes could be distinguished from each other. As outlined in previous chapters, model solutions with lower values were preferred and information criteria used to aid model selection included, Akaike Information Criterion (AIC), Bayesian Information Criteria (BIC), Chi-Square (χ^2), degrees of freedom and entropy.

Once the model with best fit to the data was identified, a series of regressions were used to examine the association between the identified latent classes and potential determinants including, demographics, harm indicators, drinking outcomes and beverage preference latent classes as previously examined in chapter 4.

6.5 Results

Descriptive statistics have been reported on the research sample in the previous chapter (please see 5.5)

6.5.1 Odds Ratios (OR)

Binary logistic regressions were conducted to identify whether any associations between the drinking indicators identified for the purpose of this study existed. Associations identified would subsequently contribute towards the full formulation of drinking latent classes.

6.5.2 Males

Unit consumption in the past 30 days (TLFB) was found to have the greatest level of association with having ever been intoxicated (ESPAD). Unsurprisingly, unit consumption was also found to be associated with positive AUDIT-C scores. In

addition to this, the AUDIT-C measure was found to be associated with drinking days in the past 30 (TLFB). Age of onset of alcohol use was not found to be associated with any of the drinking indicators examined (Table 23).

	Unit Consumption (TLFB)	Onset	Intoxication (ESPAD)	AUDIT-C	Drinking Days (TLFB)
Unit Consumption (TLFB)	-	-	-	-	-
Onset	.99 (.65 – 1.51)	-	-	-	-
Intoxication (ESPAD)	2.35 (1.53 – 3.61)	.94 (.69 – 1.32)	-	-	-
AUDIT-C	2.28 (1.15 – 4.52)	.93 (.63 – 1.36)	.32 (.22 - .48)	-	-
Drinking Days (TLFB)	.13 (.10 - .16)	.86 (.63 – 1.19)	1.26 (.89 – 1.79)	2.18 (1.35 – 3.53)	-

Table 23: Associations between drinking indicators for 14 year old males: IMAGEN Whole Sample, Odds Ratios (OR) and 95% Confidence Intervals (CI).

6.5.3 Females

When examining the female sample, the AUDIT-C measure was found to have the greatest level of association with having ever been intoxicated. AUDIT-C was also found to be associated with onset, which is in contrast to the male sample, which found no associations with age of onset of alcohol use. Unsurprisingly, unit consumption in the past 30 days was found to be associated with intoxication (Table 24).

	Unit Consumption (TLFB)	Onset	Intoxication (ESPAD)	AUDIT-C	Drinking Days (TLFB)
Unit Consumption (TLFB)	-	-	-	-	-
Onset	1.09 (.76 – 1.55)	-	-	-	-
Intoxication (ESPAD)	1.72 (1.19 – 2.50)	1.07 (.78 – 1.46)	-	-	-
AUDIT-C	.88 (.56 – 1.39)	1.81 (1.24 – 2.63)	3.77 (2.61 – 5.44)	-	-
Drinking Days (TLFB)	.02 (.00 - .04)	1.24 (.92 – 1.67)	1.34 (.96 – 1.84)	.99 (.69 – 1.45)	-

Table 24: Associations between drinking indicators for 14 year old females: IMAGEN Whole Sample, Odds Ratios (OR) and 95% Confidence Intervals (CI).

6.5.4 Model Selection

Tables 25 - 33 provide an overview of the model fit parameters for 2-3 latent class models for males, females and individual countries. As previously reported, the models were examined using a number of criteria to identify the latent class model with the best fit of the available data.

6.5.4.1 Whole Sample

Males

Model fit indices for the whole male sample latent class analysis are presented in table 24. While both the AIC and BIC indicated a superior model for a 3 class model, when

the entropy was examined, a 2 class model suggested a higher level of classification certainty when compared to a 3 class model. Furthermore, latent class probabilities revealed greater levels for a 2-class model when compared to a 3-class model. Both 4 and 5 class models were not supported by a single maximum likelihood solution. As result of these considerations a 2-class model was selected (Appendix 63).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	3774.386	3825.178	40.47	20	.94
3	3750.070	3828.566	4.15	14	.72

Table 25: Model fit indices for whole sample male latent class analysis of drinking indicators (IMAGEN)

Females

Model fit indices for the female latent class analysis are shown in table 26. Both the AIC and BIC suggested a 2 class model for the whole female sample. In contrast, the entropy results supported a 3-class model when compared to a 2-class model, although the 2-class model also produced a good level of entropy. When symptom endorsement profiles were examined further, it was found that a 3-class solution produced 3 classes with seemingly very similar endorsement profiles when compared to a 2-class model. Both 4 and 5 class models could not be adequately identified with the available data, analyses did not support a single maximum likelihood solution. Examination of both the 2 and 3 class model solutions and evaluation of the model fit indices led to the selection of a 2-class model for female adolescents (Appendix 64).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	3896.631	3948.285	65.542	20	1.00
3	3867.838	3947.667	24.74	14	.97

Table 26: Model fit indices for whole sample female latent class analysis of drinking indicators (IMAGEN)

6.5.4.2 England

Males

Model fit indices for the England male sample are presented in table 27. The AIC supported a 3-class model, while the BIC supported a 2-class model. The 2-class model was further supported by a good level of entropy, which in addition to higher level of average latent class probabilities led to a 2-class model being selected for this sample (Appendix 65).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	996.517	1032.799	27.50	20	.94
3	996.206	1052.277	15.19	14	.69

Table 27: Model fit indices for England sample male latent class analysis of drinking indicators (IMAGEN)

Females

Model fit indices for the female England sample are shown in table 28. When examining the AIC this indicated a superior model for 3 classes when compared to other models. However, a 2-class model was found to have a better level of fit when the BIC was considered. When both the entropy results and average latent class probabilities were considered, this revealed evidence to support a 2-class model for this sample. Both the 4 and 5 class models could not be converged with the available data as analysis did not support a single maximum likelihood (Appendix 66).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	1157.529	1195.443	27.11	20	1.00
3	1152.099	1210.694	9.68	14	.76

Table 28: Model fit indices for England sample female latent class analysis of drinking indicators (IMAGEN)

6.5.4.3 Ireland

Males

Model fit indices for the Ireland male latent class analysis are shown in table 29. The AIC indicated a superior model for a 2-class solution, while the BIC suggested a 3-class model having better fit for the data available. Both class 2 and class 3 had good levels of entropy, indicating high levels of classification certainty and good average latent class probabilities. Examination of 3-class model revealed small numbers of

participants, which would impact on the reliability of on going multivariate analyses. As a result, a 2-class model was selected for this sample. Neither 4 nor 5 class models could be adequately converged with the available data and was not supported by a single maximum likelihood solution (Appendix 67).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	337.497	361.497	12.19	20	.96
3	342.799	379.763	5.49	14	.85

Table 29: Model fit indices for Ireland sample male latent class analysis of drinking indicators (IMAGEN)

Females

Model fit indices for the female Ireland latent class analysis are shown in table 30. The AIC and BIC supported a 2 class model, both the entropy scores for these models were high, suggesting a good level of separation of identified classes when compared to other models. When class proportions were examined a 3 class model revealed small numbers of class members which would impact on subsequent multivariate analyses as was found in male model fit indices for the Ireland sample. This, in addition to neither class 4 nor 5 converging on a single maximum likelihood solution, led to a 2-class model being selected for this sample (Appendix 68).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	434.567	461.041	20.62	20	1.00
3	435.063	475.978	9.12	14	.93

Table 30: Model fit indices for Ireland sample female latent class analysis of drinking indicators (IMAGEN)

6.5.4.4.Germany

Males

Model fit indices for the male latent class analysis are shown in table 31. While this AIC indicates a 3-class model having the better level of model fit, the BIC supports a 2-class model. When entropy levels were examined for these classes, a 2-class model was found to have a good level of entropy when compared to other classes. In addition to this, the 2-class model was found to have greater levels of average latent class probabilities and as a result a 2-class model was selected for this sample. Neither a 4 or 5 class solution was supported by the single maximum likelihood solutions (Appendix 69).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	1969.906	2013.334	32.53	20	.86
3	1956.723	2023.840	7.34	14	.65

Table 31: Model fit indices for Germany sample male latent class analysis of drinking indicators (IMAGEN)

Females

Model fit indices for the female latent class analysis are shown in table 32. On examination of the model fit indices both the AIC and BIC supported a 2-class model solution and revealed a good level of entropy. The 3-class model similarly revealed a good level of class separation. However, the 3-class solution produced small numbers of class members for one class, which would limit further multivariate analyses. Models of 4 and 5 class solutions could not be identified with the available data and analyses did not support a single maximum likelihood (Appendix 70).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	1913.256	1957.272	28.84	20	1.00
3	1908.948	1976.972	12.53	14	.93

Table 32: Model fit indices for Germany sample female latent class analysis of drinking indicators (IMAGEN)

6.5.4.5 France

Males

Model fit indices for the male latent class analysis are shown in table 33. Both the AIC and BIC supported a 2 class solution and this was further supported by a good level of entropy when compared to a 3 class model. Both 4 and 5 class models could not be adequately identified with the available data and analyses did not support a single maximum likelihood solution. Examination of both the 2 and 3 class model solutions

and evaluation of the model fit indices led to the selection of a 2-class model for this sample (Appendix 71).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	514.928	543.585	17.28	20	.92
3	524.476	568.764	14.92	14	.59

Table 33: Model fit indices for France sample male latent class analysis of drinking indicators (IMAGEN)

Females

Model fit indices for the female latent class analysis are shown in table 34. As seen in the male France sample, both the AIC and BIC supported a 2 class solution. Entropy scores for both models revealed good levels of class separation, while average latent class probabilities further supported a 2-class model solution as being the better fit to the data available. As seen in all of the latent class analyses neither a 4 nor 5 class model could be converged with the available data and as a result a 2-class model solution was selected (Appendix 76).

Latent Classes	Akaike Information Criterion AIC	Bayesian Information Criteria BIC	Likelihood Ratio Chi-Square Test	Degrees of Freedom	Entropy
2	433.469	461.089	8.65	20	1.00
3	441.182	483.867	4.36	14	.99

Table 34: Model fit indices for France sample female latent class analysis of drinking indicators (IMAGEN)

6.5.5 Symptom Endorsement Profiles for Latent Class Models

Figures 17 to 26 present the symptom endorsement probability profiles for the 2 class model solutions outlined previously for, males, females and for each country profile (England, Ireland, Germany, France).

6.5.5.1 Whole Sample

Males

Figure 17 shows the symptom endorsement profiles for the whole male sample. Class 1 represented the smaller latent class, formed of 15% (n=106) of the total number of male participant's in the sample. A total of 7 (6.6 %) class 1 members reported having consumed 2 or more units in the past 30 days. Class 1 were found to have a higher prevalence of the endorsement for drinking days in the past 30 (61.9%) when compared to class 2. All other indicators examined demonstrated lower prevalence when compared to class 2.

Class 2 was formed of the majority of male participant's for the whole sample (n=600, 85%). Approximately a fifth of the male class 2 members reported consuming less than 2 units of alcohol in the previous 30 days (20.5%), and fewer endorsed the indicator of drinking days in the last 30 when compared to class 1 (38.1%). Class 2 revealed the higher level of endorsements for earlier onset (80.3%), having been intoxicated (74%) and scoring positively on the AUDIT C (94.1%) (Appendix 73).

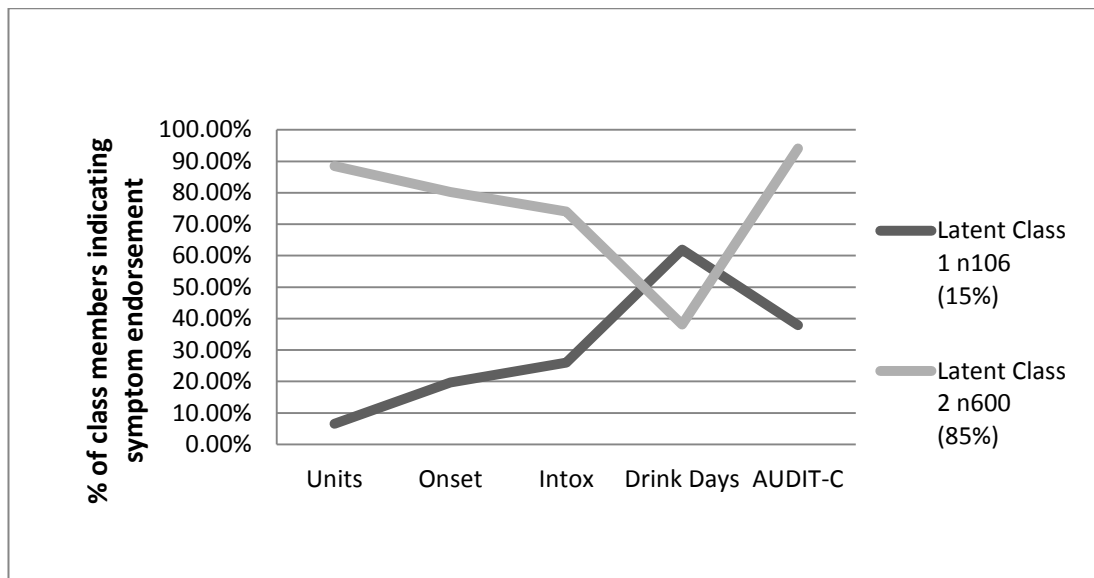


Figure 17: Symptom endorsement profile for 2 class male adolescent drinkers (Whole sample)

Females

Figure 18 presents the drinking indicator endorsement probabilities for the female whole sample. Class 1 is formed of the smaller proportion of female participant's (n 230, 33.4%) and was characterised by all members reporting having consumed 2 or more units of alcohol in the past 30 days. In addition to this, class 1 revealed overall lower level of endorsement probabilities for earlier onset of alcohol use (35.3%), intoxication (39.8%) and drinking days in the past 30 (11.6%) when compared to class 2. However, in contrast to this class 1 members revealed a higher level of endorsement for positive AUDIT-C scores (67.1%), when compared to class 2.

Class 2 was formed of the majority of female participant's from the whole sample. This class was formed of females who all reported having consumed 2 or more alcohol units in the past 30 days. Class 2 also revealed higher levels of endorsement for all other indicators with the exception of positive AUDIT-C scores (32.9%), earlier onset of

alcohol use (64.7%), intoxication (60.2%) and drinking days in the past 30 (88.4%) (Appendix 74).

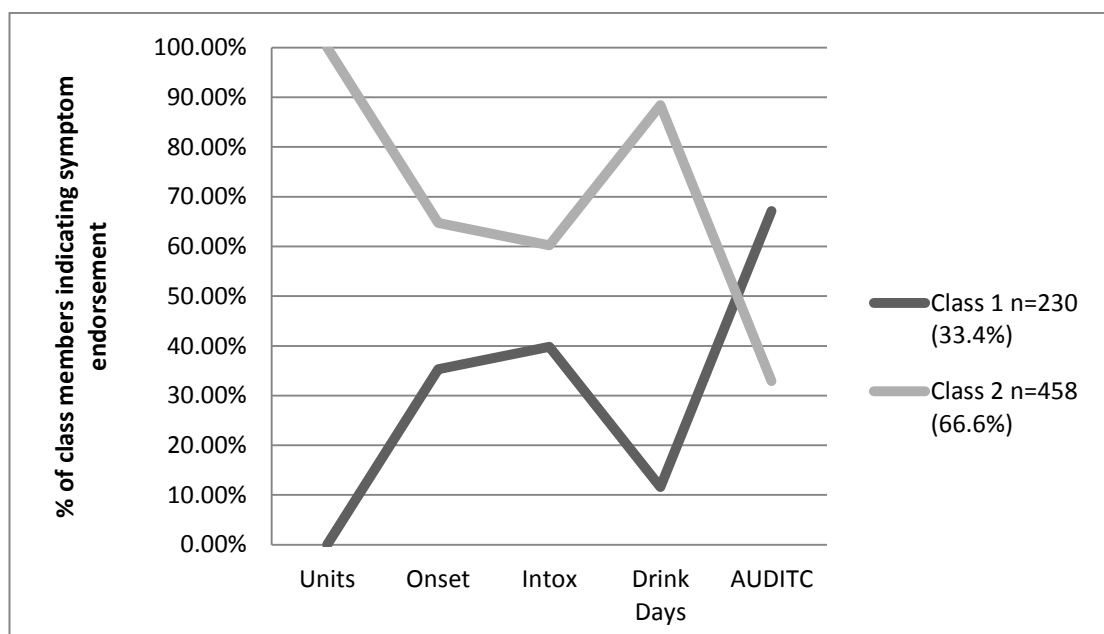


Figure 18: Symptom endorsement profile for 2 class female adolescent drinkers (Whole sample)

6.5.5.2 England

Males

Figure 19 presents the drinking indicator endorsement probabilities for adolescent males for the England sample. Class 1 was formed of the smaller proportion of male participant's (n 26, 13.%). All class 1 members reported that they had consumed 2 or more alcohol units in the past 30 days. The remaining drinking indicators revealed a lower level of endorsement probabilities, earlier onset (12.6%), intoxication (31.6%), drinking days (48.1%) and positive AUDIT-C scores (9.4%) when compared to class 2.

Class 2 (n 174, 87%) which represented the majority of male participant's within the England sample, revealed all class members to report that they had consumed less than 2 units of alcohol in the past 30 days. Class 2 was characterised by higher levels of endorsement probabilities for early onset (87.4%), intoxication (68.4%), drinking days (51.9%) and positive AUDIT-C scores (90.6%) when compared to class 1 (Appendix 75).

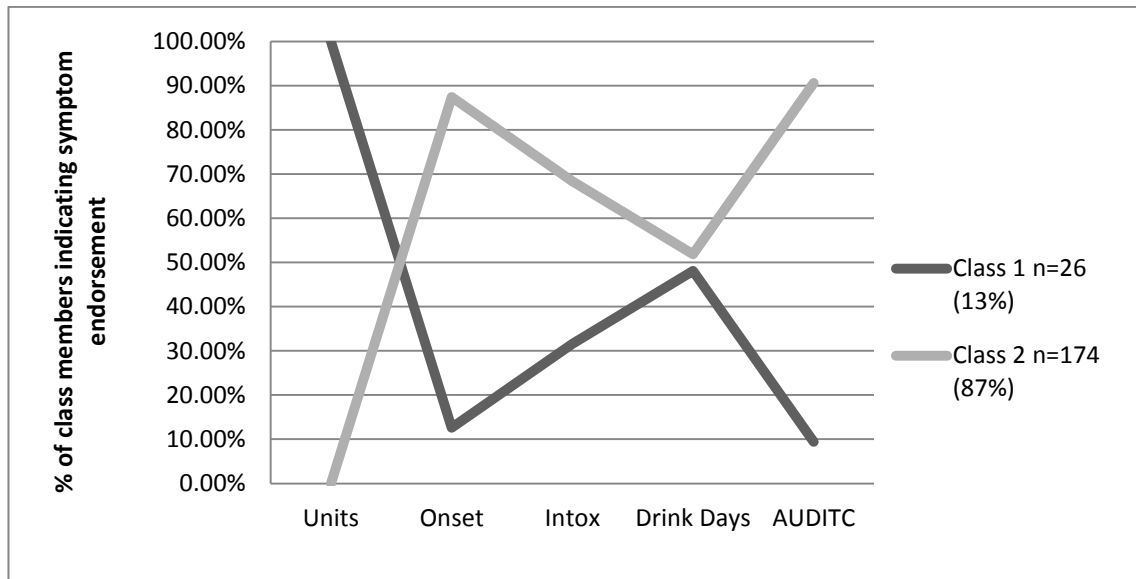


Figure 19: Symptom endorsement profile for 2 class female adolescent drinkers (England sample)

Females

Figure 20 presents the drinking indicator endorsement probabilities for adolescent females in the England sample. Class 1 was formed of a quarter of the females in this sample (n=49, 25%) and was characterised by all class members reporting that they had consumed 2 or more units of alcohol in the past 30 days, and over one or more occasions in this period. The remaining indicators revealed a lower level of endorsement probabilities, earlier onset (39.7%), intoxication (40.6%) and positive AUDIT-C scores (37%) when compared to class 2.

Class 2 was formed of the majority of females in this sample (n=147, 75%) and revealed a higher prevalence of endorsement for earlier onset (60.3%), intoxication (59.4%) and positive AUDIT-C scores (63%) while all class 2 members reported consuming less than 2 units of alcohol in the past 30 days (Appendix 76).

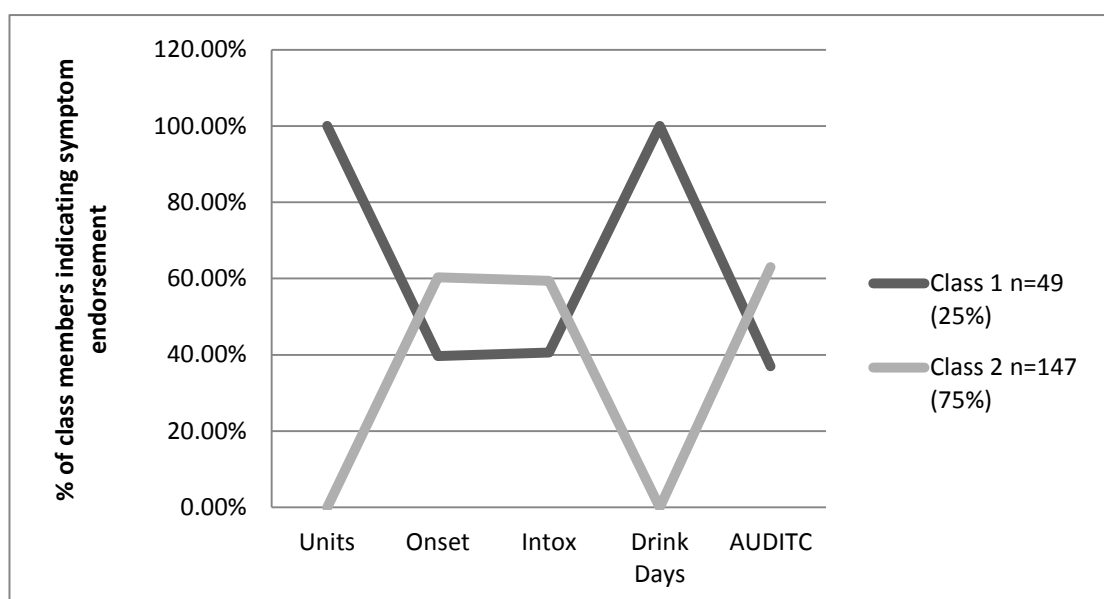


Figure 20: Symptom endorsement profile for 2 class female adolescent drinkers (England sample)

6.5.5.3 Ireland

Males

Figure 21 presents the drinking indicator endorsement probabilities for adolescent males in the Ireland sample. Class 1 formed the smaller of the male latent classes (n 27, 41.5%), and was characterised by all class members reporting that they had consumed 2 or more alcohol units in the past 30 days, over 1 or more occasions. In contrast to this, the remainder of the drinking indicators revealed the lower levels of endorsement when compared to class 2, earlier onset of alcohol use (20%),

intoxication (20%) and no group member reported scoring positively on the AUDIT-C measure.

Class 2 (n 38, 58.5%) was characterised by all class members drinking less than 2 units of alcohol in the previous 30 days. Class 2 revealed a higher level of endorsement for the early onset of alcohol use (43.3%) and positive AUDIT-C scores (23.3%) when compared to class 1, and the same level of endorsement for intoxication (20%) (Appendix 77).

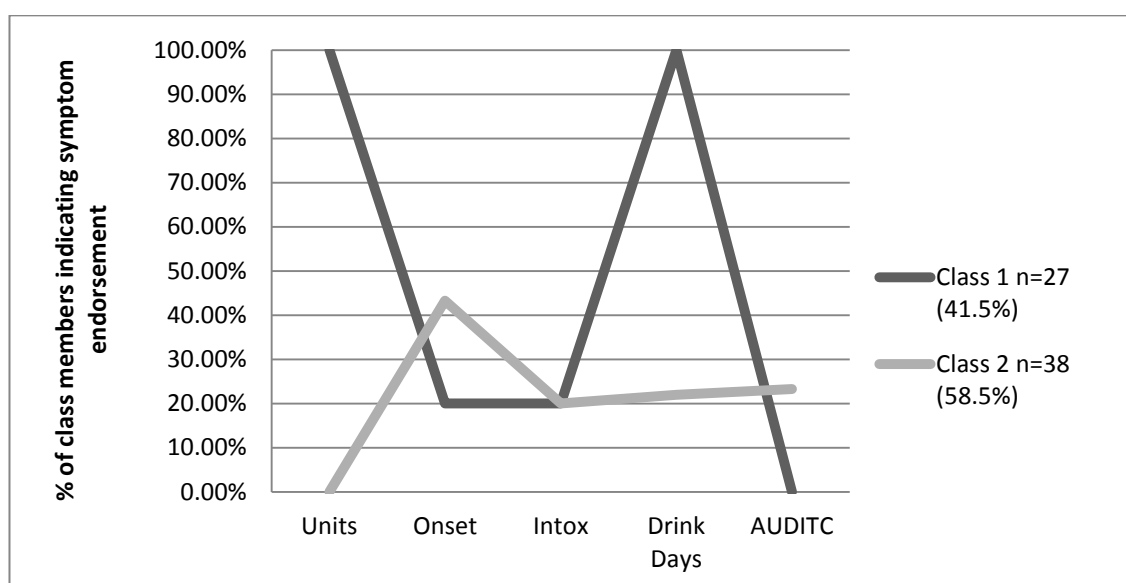


Figure 21: Symptom endorsement profile for 2 class male adolescent drinkers (Ireland sample)

Females

Figure 22 presents the endorsement probabilities for adolescent females in the Ireland sample. Class 1 formed the smaller of the female latent classes (n 23, 32.4%) and was characterised by all class members reporting that they had consumed 2 or more units

of alcohol in the past 30 days, over 1 or more occasions. The remainder of the drinking indicators examined revealed lower prevalence of endorsement when compared to class 2, onset (40%), intoxication (41.4%) and positive AUDIT-C scores (45%).

Class 2 was formed of the majority of female participants and all class members reported having consumed less than 2 units of alcohol in the past 30 days. Class 2 was also characterised by higher levels of endorsement probabilities for early onset of alcohol use (60%), intoxication (58.6%) and AUDIT-C positive scores (55%) (Appendix 78).

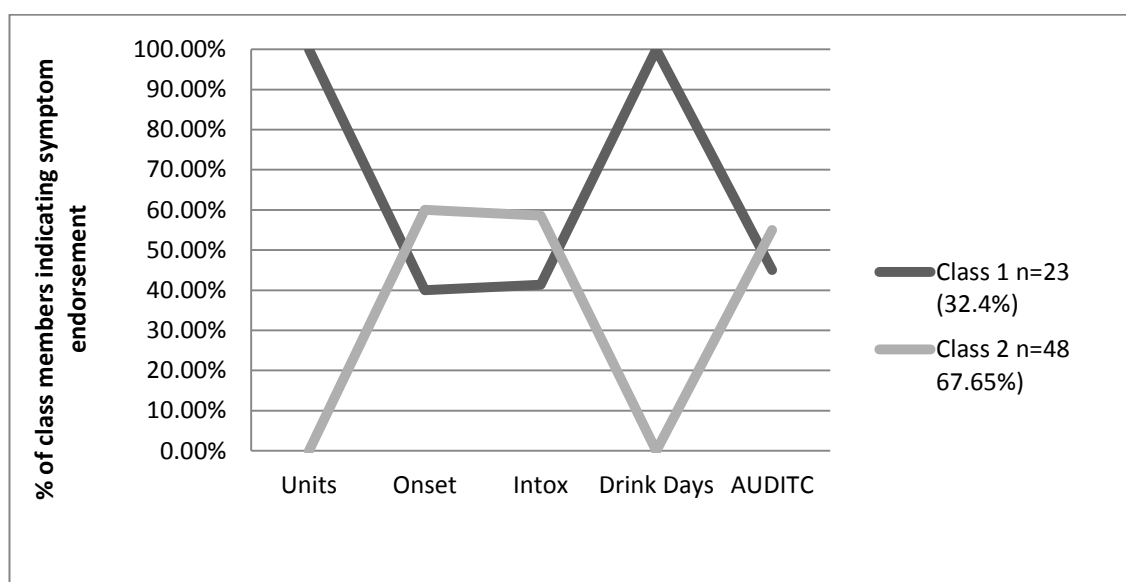


Figure 22: Symptom endorsement profile for 2 class female adolescent drinkers (Ireland sample)

6.5.5.4 Germany

Males

Figure 23 presents the drinking indicator endorsement probabilities for males in the Germany sample. Class 1 formed the smaller latent class (n 116, 30.3%) and was

characterised by all class members reporting having consumed alcohol in the past 30 days, of these, 44% reported consuming 2 or more units and 29.3% reported having been intoxicated in their lifetime. Class 1 revealed a lower level of endorsement for positive AUDIT-C scores (6.9%) when compared to class 2.

Class 2 was formed of the majority of male participant's (n 267, 69.7%) and was characterised by a low level of prevalence of endorsements including, no class members reporting consuming 2 or more units of alcohol in the past 30 days, early onset of alcohol use (38.6%), intoxication (28.8%) and drinking days in the past 30 days (1.1%). Class 2 did reveal a higher level of endorsement probability for positive AUDIT-C scores (22.5%) when compared to class 1 (Appendix 79).



Figure 23: Symptom endorsement profile for 2 class male adolescent drinkers (Germany sample)

Females

Figure 24 presents the drinking indicator endorsement probabilities for females in the Germany sample. Class 1 formed the smaller female latent class (n 75, 21.7%). All members of class 1 reported consuming 2 or more units of alcohol in the past 30 days, on 1 or more occasions. Class 1 had the lower levels of endorsement probabilities for early onset (30.9%), intoxication (39%) and positive AUDIT-C scores (30.1%).

Class 2 was formed of the majority of the female sample (n 270, 78.3%). None of class 2 reported consuming 2 or more units in the previous 30 days. Class 2 revealed a higher level of endorsement probability for earlier onset of alcohol use (69%), intoxication (61%) and positive AUDIT-C scores (69%) (Appendix 80).

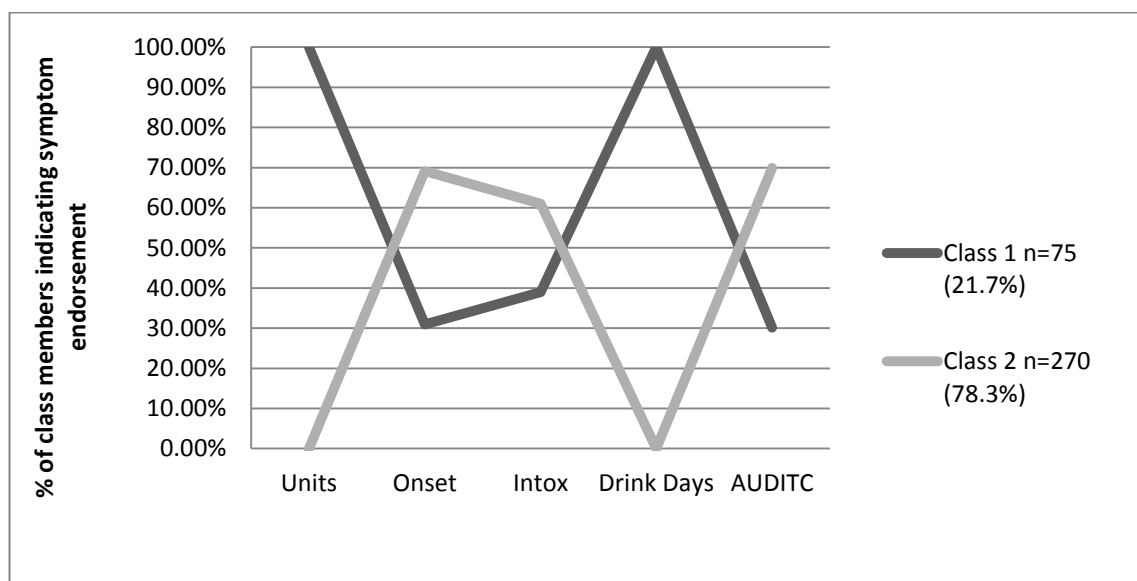


Figure 24: Symptom endorsement profile for 2 class female adolescent drinkers (Germany sample)

6.5.5.5 France

Males

Figure 25 presents the drinking indicator endorsement probabilities for males in the France sample. Class 1 formed the smaller latent class (n 20, 20%) and was characterised by higher levels of endorsement probabilities for units consumed. All class 1 members reported consuming 2 or more units of alcohol in the previous 30 days over 1 or more occasion. Class 1 revealed a lower level of endorsement probability for positive AUDIT-C scores (15%) when compared to class 2.

Class 2 was formed of the majority of male participant's (n 80, 80%) and was characterised by lower levels of endorsement probabilities for units consumed. No class 2 members reported consuming 2 or more units of alcohol in the past 30 days. Class 2 members also revealed lower levels of endorsement for early onset of alcohol use (36.3%), intoxication (20%) and drinking days (10.3%) but did reveal a higher level of endorsement for AUDIT-C positive scores (22.5%) when compared to class 1 (Appendix 81).



Figure 25: Symptom endorsement profile for 2 class female adolescent drinkers (France sample)

Females

Figure 26 presents the drinking indicator endorsement probabilities for adolescent females in the France sample. Class 1 was formed of the smaller proportion of females (n 17, 22.4%) and was characterised by higher levels of endorsement for units consumed in the past 30 days. All class 1 members reported having consumed 2 or more units of alcohol in the past 30 days, over 1 or more days. The remainder of the drinking indicators examined for class 1 revealed a lower level of endorsement probabilities for early onset of alcohol use (39.3%), intoxication (21.7%) and positive AUDIT-C scores (30.8%) compared to class 2.

Class 2 was formed of the majority of females (n=59, 77.6%) and revealed no class member reported consuming 2 or more units in the previous 30 days. Class 2 was also characterised by higher levels of endorsement probabilities for early onset of alcohol use (60.7%), intoxication (78.3%) and positive AUDIT-C scores (69.2%) when compared to class 1 (Appendix 82).

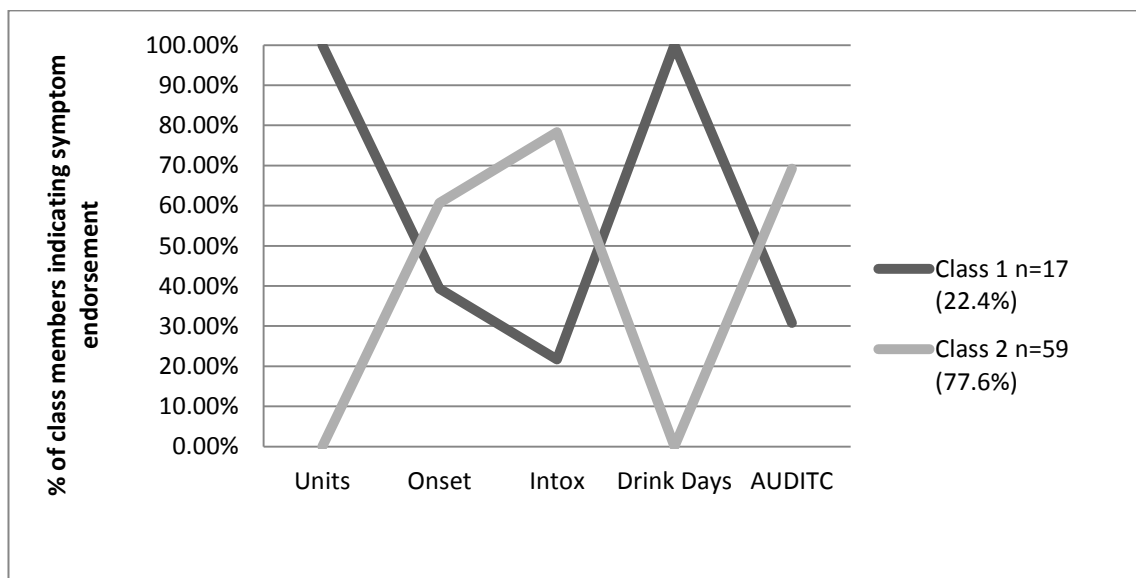


Figure 26: Symptom endorsement profile for 2 class female adolescent drinkers (France sample)

6.5.6 Latent Class Profile Demographics

6.5.6.1 Whole Sample

Males

This study sample included 706 male participants' who had consumed alcohol in the past 30 days. Class 1 (n 106, 15.0%) formed the smaller of the male latent classes and had an average age of onset of 12.49 years (SD .99). The mean age of first experience of intoxication was 13.25 years (SD 0.73). While this class revealed the higher level of average units consumed in the previous 30 days (5.23, SD 6.91), they had a lower level of positive AUDIT-C scores (n 15, 10.9%) when compared to class 2. A total of 50 (36.2%) class 1 members reported having smoked tobacco in their lifetime. Class 2 contained the majority of male participant's (n 600, 85%) with a mean onset age of alcohol use of 12.40 years (SD 1.03), and mean age of first experience of intoxication of 13.33 years (SD 0.90). Class 2 had a higher proportion of class members scoring positively on the AUDIT-C measure (n 199, 19.6%) but revealed a lower level of unit consumption in the past 30 days (0.08, SD 0.24). A similar proportion of class 2 members reported having smoked tobacco in their lifetime (n 230, 37.8%) when compared to class 1 (Appendix 83).

Females

This study sample included 688 female participants' who had consumed alcohol in the past 30 days. Class 1 formed the smallest of the latent classes in this sample (n 230, 33.4%), and had a slightly younger average age of onset (12.39 years, SD 1.02) compared to class 2. In contrast class 1 revealed an older average age of first experience of intoxication (11.77 years, SD 1.15) compared to class 2. Class 1 had the

same proportion of class member's that scored positively on the AUDIT-C (n 51, 18.8%) as class 2. However; class 1 had higher average unit consumption for the past 30 days. Just over a quarter of class 1 reported having smoked tobacco in their lifetime. Class 2 was formed of the majority of female participant's (n 458, 66.6%) and was characterised by an older average age of onset (12.50 years, SD 1.02) and younger average age of intoxication (11.61 years, SD 1.07). Class 2 revealed the same proportion of class members scoring positively on the AUDIT-C measure despite all of class 2 members reporting no unit consumption in the previous 30 days. A total of 200 participants (37.2%) in class 2 reported having smoked tobacco in their lifetime (Appendix 84).

6.5.6.2 England

Males

This study sample included 200 male participants' who had consumed alcohol in the past 30 days. Class 1 formed the smaller of the male latent classes (n 26, 13.0%), had an average age of onset of alcohol use of 12.57 years (SD 0.94) and younger average age of first experience of intoxication, when compared to class 2 of 13.06 years (SD 0.73). Class 1 had a lower proportion of class members who scored positively on the AUDIT-C measure compared to class 2 (n 3, 11.5%) but did reveal higher average unit consumption of the previous 30 day period (5.68 units, SD 7.01) when compared to class 2. A total of 10 (38.5%) class 1 members reported having smoked tobacco in their lifetime. Class 2 was formed of the majority of males in this sample (n 174, 87.0%) and had a similar age of onset as class 1 (12.47 years, SD 1.06). Class 2 revealed an older average age of first experience of intoxication (13.31 years, SD 0.80) and a larger proportion of class members scored positively on the AUDIT-C (n 29, 16.7%) when compared to class 1. However, class 2 was found to have the lower average unit consumption for the previous 30 days (0.09 units, SD 0.41). Class 2

revealed a similar proportion of members to have smoked tobacco during their lifetime compared to class 1 (n 71, 40.8%) (Appendix 83).

Females

This study sample included 196 female participants who had consumed alcohol in the past 30 days. Class 1 was formed of a quarter of female participants in the sample (n 49, 25.5%), was characterised by a younger average age of onset of alcohol use (12.34 years, SD 1.08) and older average age of first experience of intoxication (11.73 years, SD 1.12). Approximately, 1/5 (n 16, 19.3%) of class 1 members scored positively on the AUDIT-C and revealed higher average unit consumption in the previous 30 days (2.98 units, SD 4.12) compared to class 2. A total of 22 class 1 members (26.5%) reported having smoked tobacco in their lifetime. Class 2 was formed by the majority of females in this sample (n 147, 75.0%), revealed an older average age of onset (12.64 years, SD 1.05) and younger average age of first experience of intoxication (11.64 years, SD 1.11) compared to class 1. Approximately 1/5 of class 2 members scored positively on the AUDIT-C although, all members reported consuming zero units in the past 30 days. Class 2 revealed a higher proportion of participants who reported having smoke tobacco in their lifetime (n 51, 34.2%) compared to class 1 (Appendix 84).

6.5.6.3 Ireland

Males

This study included 65 male participants' who had consumed alcohol in the past 30 days. The classes for the Ireland male sample were more evenly proportioned compared to other countries samples however, class 1 formed the smaller of the two (n 27, 41.5%) and was characterised by the earliest average age of onset of use both for

the male Ireland sample and all other male samples in this study (12.0 years, SD 0.96). There were no class 1 members who scored positively on the AUDIT-C measure, despite class 1 having a higher average unit consumption for the past 30 days when compared to class 2 (6.55 units, SD 6.86). A total of 4 (50%) class 1 members reported having ever smoked tobacco. Class 2 represented the majority of male participants (n 38, 58.5%), and was characterised by an older age of onset of 12.47 years (SD 1.02). Almost a quarter (23.3%) of class 2 scored positively on the AUDIT-C measure, despite class 2 having lower average unit consumption for the previous 30 days (0.15, SD 0.33) compared to class 1 (Appendix 83).

Females

This study included 71 female participants' who had consumed alcohol in the past 30 days. Class 1 formed the smaller of the female latent classes (n 23, 32.3%) and was characterised by higher average unit consumption for the past 30-day period (5.39 units, SD 9.54). Approximately, a quarter (n 9, 26.5%) of the class scored positively on the AUDIT-C. Average age of first experience of intoxication for class 1 members was younger when compared to class 2 (11.81 years, SD 1.14), while age of onset of use was older (12.23 years, SD 0.97). A total of 15 (44.1%) of class 1 members reported having smoked tobacco in their lifetime.

Class 2 represented the majority of females in this sample (n 48, 67.6%) and had an average age of onset of alcohol use of 12.20 years (SD 1.01), which was the youngest average onset age of female latent classes across the different countries examined. A smaller proportion of class 2 members scored positively on the AUDIT-C (n 11, 22.9%) when compared to class 1, and all class 2 members reported zero unit consumption in

the past 30 days. A total of 22 (45.8%) class 2 members reported having ever smoked tobacco in their lifetime (Appendix 84).

6.5.6.4 Germany

Males

This study included 383 male participants' who had consumed alcohol in the past 30 days. Class 1 formed the smaller latent class for the male participants (n 116, 30.3%), was characterised by an older average age of alcohol onset (12.50 years, SD 1.0) and onset of intoxication (13.44 years, SD 0.71). A total of 8 (6.9%) class 1 members scored positively on the AUDIT-C and average unit consumption over the previous 30 days was 5.32 (SD 7.62), a higher average amount when compared to class 2. Class 2 was formed of the majority of male participants (n 267, 69.7%) and had a younger average age of onset (12.38 years, SD 1.04). A total of 60 class 2 members scored positively on the AUDIT-C measure and class 2 revealed low average unit consumption for the past 30 day period (0.07 units SD 0.22). A total of 113 (42.3%) class 2 members reported smoking tobacco during their lifetime (n 113, 42.3%) (Appendix 83).

Females

This study included 345 female participants' who had consumed alcohol in the past 30 days. Class 1 formed the smaller of the latent classes (n 75, 21.7%), was characterised by an older average age of onset of alcohol use (12.52 years, SD 0.97) and first experience of intoxication (11.86 years, SD 1.19) compared to class 2. A total of 22 (17.7%) class 1 members scored positively on the AUDIT-C and revealed higher average unit consumption in the previous 30 days (2.95 units, SD 4.47). A total of 22 (17.7%) class 1 members reported smoking tobacco in their lifetime. Class 2

represented the majority of females in this sample (n 51, 18.2%), was characterised by a younger average age of onset (12.48 years, SD 0.98) and first experience of intoxication (11.52 years, SD 1.01). While 51 (18.2%) class 2 members scored positively on the AUDIT-C, all class 2 members reported zero unit consumption for the past 30 days. A larger proportion of class 2 members reported having smoked tobacco in their lifetime (n 101, 36.1%) compared to class 1 (Appendix 84).

6.5.6.5 France

Males

This study included 100 male participants' who had consumed alcohol in the past 30 days. Class 1 formed the smaller latent class (n 20, 20.0%), was characterised by an older age of onset (12.37 years, 1.12 SD) and average onset age of intoxication (13.14 years, SD 0.69). A total of 3 (15.0%) class 1 members scored positively on the AUDIT-C and class 1 members revealed higher average unit consumption for the previous 30 day period (5.28 units, SD 5.01) compared to class 1. A total of 40% of class 1 members reported having smoked tobacco in their lifetime. Class 2 was formed of the majority of male participant's for this sample (n 80, 80.0%), was characterised by a younger average age of onset of alcohol use (12.28 years, SD 1.0) and onset of intoxication (13.00 years, SD .81). A total of 18 class 1 members (22.5%) scored positively on the AUDIT-C measure, although reported average unit consumption for the past 30 days was lower on average than class 1 (0.09 units, SD 0.27). Almost a quarter of class 1 (n=19, 23.8%) reported having smoked tobacco in their lifetime, this was a lower proportion compared to class 1 (Appendix 83).

Females

This study included 76 female participants' who had consumed alcohol in the past 30 days. Class 1 was the smaller of the female latent classes (n 17, 22.4%), was characterised by a younger age of onset of alcohol use (12.20 years, SD 1.08) and first experience of intoxication (11.48 years, SD 1.05) compared to class 2. Class 1 revealed higher average unit consumption (2.69 units, SD 3.73) than class 2 but had a lower proportion of class members scoring positively on the AUDIT-C (n 4, 12.9%). A total of 11 (35.5%) class 1 members reported having smoked tobacco in their lifetime. Class 2 formed the largest latent female class (n 59, 77.6%), was characterised by an older age of onset of alcohol use (12.52 years, SD 1.07) and first experience of intoxication (11.74 years, SD 1.16). Class 2 members reported zero unit consumption in the past 30 days. A total of 9 class 2 members (15.0%) scored positively on the AUDIT-C measure and a total of 26 class 2 members (43.3%) reported having smoked tobacco in their lifetime (Appendix 84).

6.5.7 Logistic Regression Analyses Odds Ratios (OR) with Confidence Intervals (CI 95%)

Key demographic data, harm indicators and drinking outcomes were compared for each of the latent classes for males, females and each of the countries examined (Appendix 85-86).

Logistic, linear and multinomial regression analyses were undertaken to explore the relationship between latent class membership, general health and functioning, cognitive functioning, alcohol use, alcohol expectations and alcohol related health

outcomes. Results for male and female participants' are presented for the whole sample and individual country profiles. Class 2 served as a reference category in the 2 class model solutions. Tables 35-36 presents significant associations for both male and female class 1 members (Class 2 in both samples served as the reference category).

6.5.7.1 Whole Sample

Males

Class 1 formed the smaller of the male latent whole sample classes (n 106, 15.0%) and revealed the higher average unit consumption for the past 30 days of the male latent classes (5.23 units, SD 6.91), when compared to class 2. The results of the multivariate regression analyses did not reveal any significant associations with any of the drinking indicators, nor neuropsychological functioning domains examined. Class 1 members were found to be 6.87 times more likely to not expect to 'feel relaxed', in addition to, expecting to 'feel hung-over' when consuming alcohol. No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 85, page 253).

Females

Class 1 female members of the whole sample represented the smaller latent class (n 230, 33.4%), had a younger average age of onset (12.39 years, SD 1.02) and higher average unit consumption in the previous 30 days, when compared to class 2. These outcomes were not found to be significantly associated with class membership in this sample. As found in the male whole sample, the results of the multivariate regressions

did not reveal any significant associations with drinking indicators or neuropsychological functioning tasks. Analyses did find associations with female class 1 members being 0.64 times more likely to report being unlikely to expect alcohol to 'harm their health', and 7.68 times more likely to meet borderline pro social functioning criteria. No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 90, page 268).

6.5.7.2 England

Males

Class 1 of the male England sample was formed of the smaller proportion of participant's (n 26, 13.0%), with an earlier average age of onset of intoxication (13.06 years, SD 0.73) and higher average unit consumption in the past 30 days (5.68 units, SD 7.01) when compared to class 2. These class characteristics were not found to be significantly associated with class 1 membership. Neither drinking nor health and social functioning indicators were found to be associated with class 1 membership. However, class 1 members were found to be significantly likely (albeit, marginally) to score a lower number of correct responses in the Pattern Recognition Memory task when compared to class 2 (β -.57, CI -16.38 - -2.87). In addition to this, class 1 members were also found to be significantly less likely to detect target sequences in the Rapid Visual Processing task when compared to class 2 (β -.49 CI, -.09 - -.01). No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 86, page 256).

Females

Class 1 of the female England sample represented the smaller latent class, with the earlier average age of onset (12.39 years, SD 1.02) and higher average unit consumption in the past 30 days, however, these indicators were not found to be significantly associated with class membership. The only indicator to be found significantly associated with class 1 membership in this sample was that class members were 4.72 times more likely to report expecting to feel that they would be 'unable to stop drinking'. No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 91, 271).

6.5.7.3 Ireland

Males

Class 1 was formed of n 27 (41.5%) of the male Ireland sample and was characterised by the youngest average age of onset, compared to class 1 and all other latent classes within this study. However, this was not found to be significantly associated with class membership. Class 1 members were found to be 2.41 times more likely to report expecting to feel 'relaxed' and .37 times more likely to report they were unlikely to 'feel happy' when drinking alcohol compared to class 2. In addition to this, class 1 members were found to be significantly less likely to detect target sequences in the Rapid Visual Processing task when compared to class 2 (β -.61 CI, -.114 - -.001). No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 87, page 259).

Females

Class 1 was formed of 23 female participants' (32.3%), with a younger average age of onset (11.82 years, SD 1.14) compared to class 2. Class 1 members were found to be negatively associated with the number of days alcohol had been consumed in the past 30 days (β 0.79, CI -.228 - -1.60), in addition to being 5.46 times more likely to expect to 'not be able to stop drinking' compared to class 2. The results of the regression analyses did not reveal any associations with neuropsychological functioning tasks. No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 92, page 274).

6.5.7.4 Germany

Males

Male Class 1 members (n 116, 30.3%) were found to have an older average age of onset of alcohol use and first experience of intoxication compared to class 2. While analyses did not reveal any associations with neuropsychological functioning tasks, they did find that class 1 members were 1.91 times more likely to have reported being intoxicated in their lifetime. Class 1 members were also .39 times more likely to not expect to experience 'health harms' when drinking alcohol when compared to class 2 members. No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 88, page 282).

Females

Class 1 females formed the smaller of the latent classes (n 75, 21.7%) and reported the higher average unit consumption in the past 30 days when compared to class 2

(2.95 units, SD 4.47). The results of the multivariate analyses revealed class 1 members to be 1.68 time more likely to report having been intoxicated in their lifetime, while were found to be negatively associated with the number of reported drinking days in the past 30 days (β -.73, CI -.27 - -1.88). In addition, class 1 members were 3.53 times more likely to expect to get into 'trouble with the police' when drinking alcohol and 3.89 times more likely to expect to feel 'unable to stop drinking alcohol'. No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 93, page 277).

6.5.7.5 France

Males

Class 1 was formed of 20 (20.0%) of the male France sample, characterised by an average older age of onset (12.37 years, SD 1.12) and intoxication (13.14 years, SD .69). Class 1 also revealed a higher average unit consumption for the past 30 days when compared to class 2, however, none of these characteristics were found to be significantly associated with class 1 membership. Regression analyses revealed class 1 members to be -0.62 less likely to report having consumed beer in the past 30 days when compared to class 2. Class members were also found to be 38.91 times more likely to report having been intoxicated in their lifetime, in addition to being unlikely to 'feel relaxed' when drinking alcohol when compared to class 2. No associations were found between class 1 membership and neuropsychological functioning tasks. No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 89, page 265).

Females

Class 1 members formed the smallest of the female latent class (n 17, 22.4%), had a younger average age of onset of alcohol use (11.48 years, SD 1.05) and higher average unit consumption for the past 30 days (2.69 units, SD 3.73) compared to class 2. While neither of these characteristics were found to be significantly associated with class membership, class 1 members were found to be associated with fewer days drinking alcohol in the past 30 in addition to fewer days smoking for the same period. Class 1 members were also 0.64 times more likely to not expect to experience 'health harms' while drinking alcohol. Multivariate analyses revealed class 1 members to be 0.23 times more likely to correctly detect target sequences in the Rapid Visual Processing task when compared to class 2 members. No associations were found to exist between these latent classes and previously defined beverage preference classes from Chapter 5 (Appendix 94, page 280).

Whole Sample			England			Ireland			Germany			France		
Variable	OR	CI	Variable	OR	CI	Variable	OR	CI	Variable	OR	CI	Variable	OR	CI
Expect to feel relaxed	6.87	1.52 – 31.04	Pattern Recognition Memory Task (PRM) % Correct	-.57	-16.38 - -2.87	Expect to feel relaxed	2.41	1.18 – 4.91	Intoxicated Occasions	1.91	1.09 – 3.35	Intoxicated Occasions	38.91	.98 – 55.65
Expect to get a hangover	.19	.04 - .81				Unlikely to expect to harm health	.37	.16 - .94	Unlikely to expect to harm health	.39	.37 – 1.48	Unlikely to expect to feel relaxed	6.77	1.51 – 30.38
						Rapid Visual Processing Task (RVP)	-.09	-.11 - .01				Expect to get a hangover	1.26	.36 – 4.42

Table 35 IMAGEN Male (Whole, England, Ireland, Germany, France) Latent Class 1 significant associations with demographics, harm indicators and drinking indicators (Odds Ratios OR, 95% Confidence Intervals CI) – Class 2 reference category.

Whole Sample			England			Ireland			Germany			France		
Variable	OR	CI	Variable	OR	CI	Variable	OR	CI	Variable	OR	CI	Variable	OR	CI
Unlikely to expect to harm health	.64	.43 - .96	Expect to not be able to stop drinking	4.72	1.26 – 17.77	Days using alcohol (past 30days)	-.79	-2.28 - -1.60	Intoxicated occasions	1.68	1.05 – 2.68	Days using alcohol (past 30days)	-.65	-2.58 - -1.55
Hyperactivity (Abnormal)	6.47	1.28 – 32.74				Expect to not be able to stop drinking	5.46	1.24 – 24.09	Days using alcohol (past 30days)	-.73	-.27 - -1.88	Days smoking (past 30 days)	-.24	-5.86 - -.43
Prosocial (Borderline)	7.68	1.35 – 43.53							Get into trouble with police	3.53	1.28 – 9.79	Unlikely to expect to harm health	.64	.43 - .96
									Expect to not be able to stop drinking	3.89	1.06 – 14.28	Rapid Visual Processing Task (RVP)	.23	.01 - .44
									Rapid Visual Processing Task (RVP)	.63	.01 - .13			

Table 36 IMAGEN Female (Whole, England, Ireland, Germany, France) Latent Class 1 significant associations with demographics, harm indicators and drinking indicators (Odds Ratios OR, 95% Confidence Intervals CI) – Class 2 reference category.

6.6 Discussion

This study applied a latent class analysis to a sample of 14 year olds (n 1557), from 4 European countries (England, Ireland, Germany, France). Participant's who reported consuming alcohol in their lifetime were examined, as to whether typologies or profiles could be identified on the basis of a limited number of drinking indicators, which adequately represent characteristics of adolescent alcohol use and misuse.

A total of 1557 (male n 748, 48.04%, female n 809, 51.96%) participant's who reported having consumed alcohol in their lifetime were included in this study. The study revealed 2 class model solutions as having the best fit for the sample data available for males and females and across all countries examined.

Males

While latent class models were established for male samples across countries and as a whole sample, with the exception of the male Germany class 1 sample, associated with having been intoxicated during their lifetime, all other male samples did not reveal any significant associations with drinking indicators or neuropsychological functioning.

In the male samples, associations were found between class 1 membership and a number of alcohol expectations (ESPAD) including, Germany class 1 being associated with not expecting alcohol use to make individuals 'feel happy' or 'harm health'. The whole male sample and Ireland sample were found to be associated with the expectation of alcohol making them 'feel relaxed'. In contrast, the France class 1

sample was found to be associated with being unlikely to 'feel relaxed' as a result of any alcohol consumption.

Male class 1 members in both the England and Ireland samples were found to be negatively associated with the Rapid Visual Information Processing task. This is a measure of how well a subject detects target sequences within the trial. It is also considered an indicator of the visual sustained attention function. This negative association when compared to class 2 suggests that class 1 in both the England and Ireland samples were found to demonstrate marginal weakness in this domain when compared to class 2 who, in comparison to class 1, characterised by lower risk alcohol drinking profiles. The England sample class 1 was also found, to have a negative association with the Pattern Recognition Memory Task, which is a reflection of the number of correct responses made in the task trials measured as a percentage. This is considered to be an indicator of visual pattern recognition.

Females

As demonstrated in the male whole sample, females did not reveal any significant associations with class membership, drinking indicators or neuropsychological functioning tasks. The female whole sample was found to be significantly associated with the expectation that consuming alcohol would be unlikely to 'harm health'.

When countries were examined separately, females in England, Ireland and Germany samples were found to be associated with the expectation that they would be likely to expect to 'not be able to stop drinking' should they consume alcohol. Ireland, Germany and France class 1 were all found to be negatively associated with the number of

drinking days in the past 30. Class 1 profiles in all of the samples examined, reflected the class with the higher average unit consumption for the previous 30 days, the negative associations found with drinking days may suggest that consumption occurs less frequently but more heavily when compared to class 2 samples.

When neuropsychological functioning was examined the only indicator associated with class membership was found in the France female class 1 sample which revealed an, albeit marginal, association with the Rapid Visual Processing Task, which measures how well the subject detects target sequences within the trial. This is in contrast to the England and Ireland male samples, which found a negative association. Females in class, 1 evidenced better overall function in this task when compared to class 2.

6.7 Limitations

Limitations of LCA have previously been outlined (see 2.6.3). The number of drinking indicators examined in this study provides a snapshot of the multitude of potentially influencing factors of young persons drinking behaviours and is unlikely to reflect the complexities of a young persons drinking profile.

All analyses resulted in 2 class model solutions for all samples and a justification for this model selection in a number of instances was that 3 class models produced much smaller third classes, whereby further multivariate analyses would be ineffectual. As such, the sample size of both the overall and individual country profiles could be considered limiting, with regards to opportunity to explore latent class models of increasing size. This may in fact produce more distinctive profiles for young people. Limitations are examined in detail in the Discussion Chapter.

6.8 Strengths

Latent class analysis was successfully applied to this sample and identified a number of distinctions between the sample and classes examined. The successful establishment of latent classes drawn, from a limited number of drinking indicators in young people from across 4 European countries, may be suggestive of underlying unobserved categorical variables. This mean of characterising could be used to divide a population into 'mutually exclusive and exhaustive' latent classes.

Strengths of this study include the addition of the neuropsychological function data, which allows for consideration for a more detailed understanding of drinking indicators and patterns. This may theoretically be more likely to impact of neuropsychological functioning of a 14 year old, when compared to typically described quantity/frequency measures of alcohol consumption. While analyses identified a small number of marginal differences in some tasks when examining, whole and individual countries latent classes, inclusion of such data seeks to build on the limited number of studies exploring the effects of alcohol use on both the development and neuropsychological functioning of adolescents. Strengths are examined in detail in the Discussion Chapter.

6.9 Conclusions

Latent Class Analysis identified a series of underlying subgroups of adolescents characterised by a limited number of drinking indicators and demonstrated a level of generalisability to wider adolescent populations. Echoing the findings of the previous studies (see Chapters 3-5), a number of subtle differences were observed within latent classes, including lower probability of 'higher risk' drinking being assigned to class 1.

The data revealed latent classes with varying levels of risk associated with class membership, while a number of drinking indicators, neuropsychological functioning tasks and beverage preference were not found to be significantly associated with class membership. Analyses did reveal a number of distinctions between, and within country profiles in addition to observed gender differences.

The impact of alcohol use on the neuropsychological function of the participant's revealed a limited amount of information in this regard. While some small variations were noted between the higher and lower drinking classes in some samples, these were marginal and may be limited in terms of the conclusions that can be derived from the results. However, distinctions albeit small, were evident and consideration as to the role of alcohol in these circumstances and how this can be used to inform future research is discussed in the concluding chapter.

While associations were inconsistent between countries and genders, this could reflect the complex nature of adolescent drinking behaviours, which are unlikely to be fully captured through existing screening and assessment tools. This in turn, is likely to limit how much of an individual's drinking typology or profile could be reflected through a latent class analyses approach. Small sample sizes, in individual country analyses could also reduce power needed to detect effects. Regardless of these limitations, latent class analyses could provide new information on underlying, unobserved variables pertinent to adolescents who may be embarking on their first alcohol using experiences. This information may be indicative of the early formation of drinking patterns, which, in turn may provide new information with regards to how these drinking characterisations may evolve through the transition into adulthood.

Chapter 7: Discussion

7.1 Introduction

Studies presented in this thesis provided a unique opportunity to draw from two large cohorts of adolescent's from two well-established research programs. The overall aim was to examine whether distinct subgroups of adolescent's could be identified on the basis of a series of limited indicators of alcohol consumption. Latent Class Analysis (LCA) provided a contemporary approach in the exploration, formulation and development of an empirically derived multi-dimensional measurement of alcohol use patterns in adolescents. This was subsequently used to examine the impact of distinctive patterns and key indicators on neuropsychological functioning in this cohort. This thesis set out to answer the following questions:

- Can qualitatively distinct subgroups of adolescent's attending EDs in England be identified on the basis of their use of different beverage types?
- Can a latent class structure adequately represent the heterogeneity in drinking behaviours in adolescent's attending EDs in England?
- Can latent structures derived from a limited number of drinking indicators be generalised to other nationalities of young people?
- Can a latent class structure adequately represent subgroups of adolescents who consume alcohol based on a series of drinking indicators, which can be used to examine neuropsychological function in young alcohol users?

7.2 Summary of findings

7.2.1 Can qualitatively distinct subgroups of adolescent's attending EDs in England be identified on the basis of their use of different beverage types?

Alcohol use and related harms remain commonplace within EDs in England, but are not typically the main reason for presentations in young people. While 'injuries' have been revealed as the most common reason for attendance, and more likely to be sustained when under the influence of alcohol, what has remained unclear are the number of young people who present at these services who may also be using and/or misusing alcohol. This thesis revealed that around a quarter of young people attending EDs in England reported having consumed alcohol in the past 3 months, and of these, 76% had tried alcohol before the age of 15. While young people do not comprise the majority of ED attenders, the setting itself - as highlighted in this thesis, can provide a rich data source for researchers examining alcohol use and related harms in adolescents.

National surveys have reported that while the majority of EDs ask young people about their use of alcohol, few are doing so as part of a clinical routine (Patton, 2016). In addition, current screening and assessments of alcohol use, while validated in this population, have been largely developed and standardised on the adult clinical population and may not be equipped to capture the subtleties of young people's drinking behaviours.

This thesis has demonstrated a range of distinctive drinking patterns and profiles, which exist among adolescent populations and provides further evidence that

adolescent's are more likely to drink more than one type of alcoholic beverage with observed differences in both age and sex. Studies also supported the notion that consuming more than one type of alcohol can itself increase an individual's risk of harmful drinking. Males and females presented differences in beverage preference and associated risks, which may be indicative of underlying subgroups, which can be characterised by beverage type consumption. While analyses revealed small variations in male beverage type consumption, females were noted to have a wider drinking repertoire when compared to the males, which may suggest that they are more likely to switch between drink types. Room and colleagues (2011) suggested this pattern can present more 'problematic drinking' behaviours. This could imply that existing subgroups characterised by beverage type may be more relevant in young female drinkers.

Nevertheless, this research did find that a series of underlying unobserved categorical variables of beverage type could be used to divide a population into 'mutually exclusive and exhaustive' latent classes, and provide new information on existing population subgroups. While more extensive clinical screenings and assessments can provide a greater level of clinical detail on a young persons drinking behaviour, this simple recall of beverage types consumed within a given time period has been found to provide key indications of a 'type' or 'profile' of a young alcohol user. Beverage type consumption questions with simple 'yes/no' answers may be a 'softer' way to open a dialogue around alcohol use with a young person who is likely to be unfamiliar, and potentially more cautious around the clinical questioning of their alcohol use. This approach may be a more effective means to engage a young person in these discussions, which in turn may prompt further assessments and support where deemed appropriate.

7.2.2 Can a latent class structure adequately represent the heterogeneity in drinking behaviours in adolescents attending EDs in England?

This thesis has outlined a number of screening measures and assessments currently in practice and highlighted the variability that exists among many of the clinical tools available. In addition to assessments having been predominately developed and standardised in adult populations regardless of validation for use in young people, it is widely acknowledged that clinical assessment criteria can perform differently across age groups, particularly when developmental, personality and social factors in young people are considered.

This research proposed that the identification of distinctive alcohol drinking patterns in adolescent's, derived from a series of key multivariate indicators instead and/or in addition to the more traditional quantity/frequency measures, could enable researchers and clinicians to identify alcohol problems at an earlier stage.

The characterisation of adolescent alcohol use consists of a diverse and complex array of multivariate indicators that existing screening tools and assessments are unlikely to capture. Data from this large cohort of adolescent's presenting at EDs in England, provided a unique opportunity to apply a latent class structure as an alternative method of conceptualising this population. What was replicated from the previous study was that males demonstrated less variation in the endorsement of drinking indicators, with fewer associated harms when compared to females. This furthered previous indications of an apparent heightened risk in some areas of health and social functioning for alcohol consuming female adolescents. In addition, there were also subtle differences noted within the latent class structures, including smaller proportions

of participant's demonstrating 'very high risk' drinking behaviours. While subgroups of adolescent's could be characterised by a limited number of drinking indicators, which may not only be admissible to this sample but generalised to wider adolescent populations, this may not always be appropriate when examining exceptionally high-risk alcohol users which could be 'lost' among larger cohorts.

Latent class analysis provided new information on a number of underlying unobserved variables affiliated to young people presenting at EDs in England who may or have recently established early patterns of behaviours in the use or misuse of alcohol.

7.2.3 Can latent structures derived from a limited number of drinking indicators be generalised to other nationalities of young people?

As found in England, adolescent's in the European countries examined as part of this research were more likely to have consumed more than one type of alcoholic beverage with observed differences in gender, and be more likely to experience the harms related to alcohol use from a given volume when compared to other age groups. A central component of this thesis was to examine at to whether previously formed latent structures derived from a limited number of drinking indicators, including beverage type could be generalised to other nationalities of young people suggesting possible intrinsic characteristics of this populations drinking patterns.

While a range of beverage types were consumed across the European samples, participants were also noted to report the same order of initiation for each of the beverage types examined. Furthermore, participant's revealed similar average age of

alcohol use onset, with short time periods between the initial use and first experience of intoxication. The onset of alcohol use in adolescence may subsequently present an important time in which the delivery of health education could limit, or postpone intoxication in young people with added potential benefits for the neuro-developmental processes occurring during this time.

A number of consistencies and differences were noted in the younger European samples. This younger cohort (14 years) revealed similar proportions of each beverage type being consumed when compared to older adolescent cohorts. This may indicate that beverage preferences emerge over a period of time from initial onset of use, and may not be indicative of a particular drinking typology or profile in younger age groups. Furthermore, it remained apparent that beverage type may have greater influence on drinking profiles in females when compared to males, suggestive of a greater level of risk associated with beverage type consumption in adolescent females.

Both the identification of beverage type consumption and the latent conceptualisation of this aspect of a young persons alcohol use could be generalised to wider populations. This could inform a joined up, consistent approach and directive for clinicians, researchers and policy makers highlighting the importance of emerging drinking preferences in young people. This in turn could be used to inform or tailor screening, assessment and delivery of health advice in the quest to prevent, or minimise the use and/or misuse of alcohol in adolescence.

Today's understanding of neuronal and developmental damage associated with alcohol use is primarily drawn from adult clinical populations. While similarities have been drawn between adult and adolescent neuronal structures, research has also advanced

its understanding using neuroimaging techniques and demonstrated adolescence to be a critical period of development. The initiation and continuing use of alcohol may have unique detrimental consequences on the adolescent brain structure and neurocognitive functions at a critical time of neurodevelopment and transition, when compared to adults.

Neuroimaging techniques have enabled researchers to examine the structural changes in the adolescent brain, while cognitive assessments have shed some light on the functional components of these neuronal constructs. However, these methods may remain limited in their scope to detect subtle changes in these early stages and any subsequent impact of alcohol use.

7.2.4 Can a latent class structure adequately represent subgroups of adolescents who consume alcohol based on a series of drinking indicators, which can be used to examine neuropsychological function in young alcohol users?

This thesis sought to explore the characterisation of alcohol use in adolescents, and examined the impact of alcohol consumption on neuropsychological functioning. The final study explored whether previously developed latent class structures could be applied to a new sample of adolescent's derived from four European countries, and adequately represent the heterogeneity in drinking behaviours.

The systematic review conducted in this thesis reviewed 17 studies and examined the neuropsychological impact of alcohol on the adolescent brain within the cognitive domains of, executive function, attention, inhibition, visuo-spatial, memory,

affective/impulsivity and decision/risk taking. The review revealed disparate findings in all of the cognitive domains examined, nevertheless, studies did note some consistencies in cognitive impairments found in heavier drinking adolescents in these cognitive domains.

Highlighted in a number of the studies reviewed, was the fact that while researchers have begun to identify some differences in neuropsychological function in adolescents who use alcohol, our understanding of this unique complex neurological developmental period is limited. It was also noted that while examining the early stages of alcohol initiation, any neuropsychological impacts that may occur, are likely to do so over a period of time, and as such are unlikely to manifest in observable differences at this early stage.

This thesis found a small number of significant associations with the neuropsychological functioning tasks examined. Both the England and Ireland male higher risk drinkers (class 1), revealed negative associations with the Rapid Visual Information Processing task. This measure is a test of visual sustained attention, which is sensitive to dysfunction in the parietal and frontal lobe areas of the brain, and is considered a measure of general performance. The score derived from this task reflects the individual's ability to detect target sequences. The England male higher risk drinkers (class 1) were also found to score significantly lower on the Pattern Recognition Memory task when compared to low risk drinkers (class 2). The score reflected the percentage of correct responses in this task. These findings contrast with Tarter et al, (1995) previous findings, which found female substance users to score, lower in tasks examining attention. However, the findings in this thesis do support a

number of studies, which have found decrements in attention in alcohol using adolescents (Tarter et al., 1998; Sequalia et al., 2009; Peeters et al., 2012).

The only female sample to reveal any significant association with neuropsychological functioning tasks was the France high risk drinking class (class 1). This class revealed a positive association with the Rapid Visual Processing task. This contrasted with results noted in the male England and Ireland samples, as it revealed the higher risk drinkers to produce a higher percentage of correct responses in the task trials.

While associations were found within these samples they were marginal, and comparisons with previous studies are limited in terms of the conclusions that can be derived from the data, due to the disparate nature of findings. Nevertheless, distinctions albeit small, were evident and can be used to inform future research, which builds on our understanding of neuropsychological function in young alcohol users.

7.3 Findings in relation to previous research

Adolescence presents a unique time of neurodevelopment and as such, the initiation and continuing use of alcohol may have detrimental consequences for the vulnerable adolescent brain structures and neurological functioning. Current UK guidelines recommend that if young people drink it should not be before the age of 15. These studies found the majority of adolescent's had consumed alcohol before the age of 15 years and that alcohol use and related harms were highly prevalent in this population group. This supports previous research, which revealed the majority of young people report consuming alcohol before the age of 15, with high prevalence rates of hazardous drinking in this population (WHO, 2014, ESPAD, 2011, Fuller, 2013).

The Guideline Development Group stipulated that in the assessment of alcohol problems in children and young people other co-morbid, social, developmental, educational and motivating factors should be considered in the overall assessment of risk and presence of AUD diagnostic criteria (NCCMH, 2011). This study also revealed that while current screening and assessments may be able to capture the more traditional diagnostic criteria, there are evidently a number of subtle distinctions in the characterisation of drinking patterns in adolescent's, which have yet to be examined.

Previous research, outlined in this thesis examining neuropsychological development in young people who consume alcohol is limited. Studies including those examined in the literature review were often impeded by small samples, confounding poly-substance use, psychiatric co-morbidity and unclear dose-response relationships (Peeters et al. 2014). Similar to previous research, albeit with larger samples, limitations were still apparent in this study when samples were subdivided into smaller subgroups, that meant outcomes had to be interpreted with some level of caution. Results examining neuropsychological function supported the findings of Tarter et al. (1998), Squeglia (2012) and Peeters (2012), which found decrements in attention, based tasks. These findings contrasted with those of Hanson (2011), who found no decrements in attention in alcohol using adolescents. This study found decrements in attention tasks in male participant's and a higher proportion of correct responses in the female France sample, which contrasts with Tarter (1995) findings of decrements specific to females only. While a number of significant associations were found between latent class membership and neuropsychological functioning in attention and memory tasks, these were marginal and the disparate nature of the findings are limiting in the conclusions which can be drawn.

Nevertheless, this study supports the examination of early neurocognitive changes in large cohorts of young people in the promotion of understanding early onset of 'alcohol induced neuropsychological impairments'. This could ultimately inform alcohol consumption guidelines and practice to improve outcomes and prevent or reduce alcohol use and harm in this population, at a time when reversibility may still be possible.

7.4 Limitations and strengths

7.4.1 limitations

The paucity of research and disparate findings of the impact of alcohol use on neuropsychological development has proved challenging when drawing comparisons with previous studies. Statistical methods, which use categorical data, require careful re-coding of continuous data to ensure that categories remain meaningful and any substantial loss of information is avoided. Furthermore, while latent class analysis allows for an exploratory approach in the selection of variables, which are deemed to hold influence in the area of research, this selection of variables are often dependent on researchers own drawn conclusions. This lack of standardisation means the selection and definition of variables, which are subsequently used to formulate drinking profiles and typologies, can make drawing comparisons between studies difficult. Further care is also required when generating hypotheses and research questions to ensure that these are not formulated in order to conform to the data available, particularly pertinent in this thesis, which has used secondary data.

Further information constraints are noted in the classification of class membership among participants, in so far as while latent classes are formed of those participant's who possess the highest probability of belonging to that class. However, this does not account for the fact the same individual may also have a (albeit lower) level of membership probability assigned to the other classes. The latent class model will simply indicate sole class membership.

The exploratory nature of latent class analysis does not allow for causality to be inferred, the interplay of internal and external factors of a young persons alcohol use are unlikely to be fully represented by a discrete number of drinking indicators. Limitations in secondary data may also dictate which indicators are examined and as such, there may be other constructs not measured in this thesis, which could better predict alcohol consumption and its impact on neuropsychological functioning in adolescent's.

While the data sets used in this thesis are some of the larger available, which have examined alcohol use and neuropsychological functioning in adolescents, limitations were still met in Chapters 5 and 6 whereby, latent class analyses resulted in the consistent selection of 2 class models. In some instances this was informed by the need to avoid small sample sizes to ensure subsequent multivariate analyses could be applied, and resulting odds ratios should be interpreted with caution. In addition, smaller sample sizes in individual country analyses could lead to reduced power to detect effects, while multiple comparisons could lead to type II errors. There were limitations with regards to the opportunity to explore latent models of increasing sizes, which may have revealed additional information on the drinking typologies in these cohorts.

While the final study in this thesis sought to examine the neuropsychological impact of alcohol on the adolescent brain, this was limited to a series of cognitive assessments derived from a single battery (CANTAB). While results were consistent in terms of their disparity when compared with previous research, results were also limited in terms of conclusions, which could be drawn from the data available.

Large datasets of 'non clinical' young people who consume alcohol is highly sought, however data obtained using assessments originally designed and developed on adults may be unable to capture the subtleties one may expect to find in the emerging and exploratory behaviours of a young persons alcohol use. While differences were found in some areas of neuropsychological function in this cohort, differences observed were small. Furthermore, while over 75% of participant's who reported having ever consumed alcohol, first did so before the age of 14, these early stages of alcohol consumption and any subsequent impacts are unlikely to be fully established. Assessments and tools currently available – while advancing, may not be equipped to capture such subtle changes in functionality.

There may be some limitations in terms of how well adolescent's attending EDs and those attending schools represent adolescents more generally, while the self-report nature of the surveys used may have implications for the reliability of the data obtained. While attempts were made to ensure privacy and confidentiality were maintained, self-completion of surveys may carry biased estimates. In addition, there is a potential for recall bias in this population with the possible over, or under reporting of alcohol consumption as a result of social desirability bias (Smith et al., 1995; Barbor et al., 1987).

Co-morbidity also presents a particular problem in young people (Welch, 2009). To elucidate the true effect of alcohol on neuropsychological functioning, accounting for and measuring confounds which frequently present in adolescent substance users including, other drug use is important. In the ESPAD 2011 survey, tobacco was found to be the most commonly used substance, followed by alcohol and cannabis. Approximately 9% of 15-16 year olds students who took part in the study reported using 2 or more substances. The prevalence of 3 or more substances was 3.5%. Studies have shown marijuana use during adolescence to also be associated with impaired cognitive functioning (Squeglia, 2009). However, by excluding participant's for confounds including other drug use, this may in turn limit the generalisability of results (Squeglia, 2009).

SIPS Junior did not collect data on other substance use other than tobacco and while the IMAGEN study did collect this data, rates of use were low among the sample of 14 year olds. For the purpose of this thesis, studies examined whether latent structures could adequately represent subgroups from across both datasets and as such, other drug use was not included so as to maintain the latent structure in all subsequent analyses.

Nevertheless, poly drug use is an increasingly common phenomenon among European young people and future studies should look at the co-occurring effect of alcohol with other drugs (Hibell, 2011).

7.4.2 Strengths

This was the first study to examine whether distinct groups of adolescent's presenting at EDs in England could be identified on the basis of beverage type, and a limited series of indicators of alcohol consumption. The exploratory nature of latent class analysis provides a flexible methodology when examining both observed and unobserved variables, which sets it aside from the more traditional analysis techniques. Its strength lies in its ability to provide a comprehensive means to identify a set of underlying subgroups into 'mutually exclusive and exhaustive' latent classes, which is not reliant on standardised variables when examining a behavioural phenomenon, such as alcohol consumption in young people. A further strength of this analyses in the characterisation of young people, is the person centred approach it adopts when dividing a sample into latent classes, by focusing on the relationships between individuals who present similarly in terms of drinking patterns and behaviours, in a way which traditional clinical measures don't typically capture.

Latent class analysis was successfully applied to a large cohort of adolescent's attending EDs in England, and a series of underlying subgroups characterised by beverage type and limited number of drinking indicators were found to be associated with varying levels of risk. Distinctions between males and females in both studies drew particular interest, as females were consistently noted to exhibit an increased level of risk in a number of harm domains, which may be indicative of gender specific harms for this population.

This thesis also presented the first study, which sought to characterise alcohol use in adolescent's from across four European countries. The opportunity to identify early neurocognitive changes associated with alcohol use in a large European sample of

young people presented a unique opportunity to advance our understanding in this notoriously under researched area. Latent class analyses provided further evidence of existing underlying categorical variables in alcohol using adolescents. These unobserved variables were used to divide an adolescent cohort into latent classes representing beverage type use and/or capture key indicators of alcohol use pertinent to this group. Consistencies were found with previous studies within this thesis, which revealed differing typologies both within classes and between genders. Males and females across countries were observed to form classes of low and high-risk drinkers, albeit derived from variables embedded within assessments currently used in practice. This series of studies presented a contemporary, alternative method of conceptualising this population group, examining how individuals were both similar and different to each other with regards to their own drinking typologies, both within and across different countries.

These series of studies were further strengthened with the addition of comprehensive cognitive data derived from the first multicentre, functional and structural genetic-neuroimaging study of a cohort of 2000 14-year-old adolescents.

Large datasets, such as those described in this thesis have provided a rich source in order to further our understanding of alcohol use, and its impact on neuropsychological function in adolescents. While secondary data has its limitations with regards to the extent to which indicators are included in data collection, a notable strength of these studies is that the data is drawn from programmes, which have been designed to examine this phenomenon in adolescence.

7.5 Future Research

This thesis points to a continuing paucity of research examining the impact of alcohol on the neuropsychological development and functioning in adolescents. While mounting, research aimed to develop our understandings of neurological development, function and identification of elusive neurobiological markers remains of paramount importance when developing hypotheses and interventions in future research.

Research has shown that adolescence is not synonymous with puberty and that neuronal development is not completed until mid to late twenties. As such, large longitudinal studies which reflect a lifespan perspective enable researchers to examine premorbid cognitive function weaknesses, which may produce or exacerbate neurological vulnerabilities in adolescent's alcohol using behaviours, incorporate lifetime abstainer groups and minimise the impact small samples, and co-founding factors can bring to findings.

While young people make up a smaller proportion of overall ED presentations this does not detract the role ED settings can play in the identification, assessment and intervention of alcohol use/misuse in adolescents. National surveys (Patton, 2016) have revealed that the delivery of screening and assessment of alcohol use in young people could be vastly improved upon. Future studies should consider how both the ED setting can maximise the teachable moment to engage young people in discussions around alcohol, in addition to how best this can be incorporated in screening and assessments.

Consistencies in both the collection of data and assessments used to examine alcohol use in this population will enable more effective and informative comparisons to be drawn. Design and development of alcohol use and neuropsychological function measures for adolescents, as opposed to validating those drawn from research conducted in adults, may prove to be more adept at capturing the subtleties of developmental differences in adolescents, which may currently be overlooked with current methods.

Future studies examining alcohol use in young people should consider applying latent class analyses in terms of advancing exploration into potential indicators embedded within adolescents patterns of alcohol use. These methods can be used to identify subsets of adolescents who differ in their risk of experiencing alcohol related harms, neuropsychological function and other health outcomes. These approaches could also support research to offer further insight into how early patterns of alcohol use may translate as the young person transitions into adulthood. More latent class research would provide opportunity to establish the optimum number of subgroups of young alcohol drinkers. Future studies examining the characterisation of drinking patterns should consider the methodologies used in this thesis so that comparisons can be drawn.

Early onset of alcohol use is associated with longer-term alcohol problems (WHO, 2012) and continuing research that spans this developmental period is needed to better establish early markers associated with neuropsychological development in young people. Given the lack of longitudinal cohort studies it would be desirable for future research to identify young people before the onset of alcohol use. This would enable any pre-morbid cognitive function weakness to be examined prior to any initiation of

alcohol, which may exacerbate any neurological vulnerability. Furthermore, studies following young people before the onset of alcohol would provide lifetime abstinent participants as a control group.

Findings presented in this thesis found young people to be more likely to drink more than one type of beverage compared to adults. Surveys that include questions on drink type consumption, could serve to broaden our understanding of characterisations of drinking patterns in young people. Results of this thesis indicated that beverage preferences may emerge over a period of time, and may not be indicative of a particular drinking typology or profile in younger age groups. While greater variation and associations with harm outcomes were found in females when compared to males. Future studies, may wish to incorporate comprehensive information of beverage types consumed. This could offer insight into the role of emerging preferences, patterns and associated neuropsychological decrements, which may be indicative of an individuals future drinking patterns and risk of harms.

7.6 Implications for practice

The WHO (2010) Global Strategy to Reduce the Harmful Use of Alcohol states that the protection of vulnerable populations who are at greater risk of alcohol related harms, including young people, should form an integral component of health policies aimed at reducing alcohol use.

The DSM and ICD criteria were both developed for psychiatric diagnoses in adult populations, and as a result hold considerable limitations in the application to adolescent populations. In addition, clinical assessments consist of a number of

diagnostic symptoms, which could both be considered developmentally normative for adolescents, or not typically experienced by adolescents, which could distort clinical understandings of a young persons alcohol use.

UK guidelines for young people have now been established and recommend an alcohol free childhood. It also recommends that young people who choose to consume alcohol should not do so before the age of 15, not exceed adult daily unit recommendations and on no more than one occasion per week (Donaldson, 2009). The adult UK drinking guidelines underwent review in 2016, which resulted in the amendment of new weekly guidelines, outlined in the introductory chapter of this thesis. Despite this comprehensive review and changes in the adult guidelines, adolescent guidelines are yet to be reviewed and at present remain out dated with regards to the advice on consumption levels for young people.

The data derived from the Sips Junior research programme revealed rates of consumption increased considerably with age, ranging from 4% for those aged 10 to 90% of those aged 17, a rate which is comparable to those found in school studies. As this research has shown, high prevalence of alcohol use among adolescents, associated with a number of harms, are evidently not restricted to those who initiate early alcohol use. The increase in rates of consumption over this critical developmental period and continuing use of alcohol may have detrimental consequences for vulnerable adolescent brain structures and neurocognitive functioning. While results presented in this thesis do not establish causality, this period presents an immense opportunity to prevent, or reduce alcohol related harms at a time where reversibility of harm may still be possible.

The Guideline Development Group (GDG) highlighted in 2011 that clinical tools appropriately validated for use in young people should be used in conjunction with information on other co-morbid, developmental and social factors pertinent to the young person. This thesis proposed that the identification of multivariate indicators could provide new information on the distinctive features of alcohol use in adolescents, which could broaden insight and depth to current assessments. Health advice, prevention or reduction of alcohol related harms could be tailored accordingly.

7.7 Conclusions

Drawing from two large cohorts of young people at an important developmental milestone, this thesis sought to provide novel information on the characterisation of alcohol use patterns and the impact of alcohol use on neuropsychological functioning in adolescents.

Studies revealed a quarter of young people attending EDs in England had consumed alcohol in the previous 3 months, while the majority had first consumed alcohol before the age of 15. European samples revealed comparable proportions of young people consuming alcohol and equally high proportions having done so before the age of 15.

Current understandings around adolescent drinking patterns have been largely formulated using measures originally designed and developed for adult clinical populations. This has led to a distorted clinical understanding of this population groups drinking patterns and related harms. While these validated measures can offer information on drinking patterns, conceptualising young people as 'mini adults' is

unhelpful. Despite similarities in patterns and harms having been identified in adults and adolescents, the fine-grained characterisations of young persons first use and early experimentation with alcohol is unlikely to be captured with current methods.

Disparity in the characterisation of young people's drinking patterns are likely to impact on how phenomena associated with this area of research, including neuropsychological functioning and development are also understood. Latent class analysis offers a contemporary approach, which could help advance understandings in the characterisation of adolescent drinking patterns. It highlights the value in examining the components of adolescent alcohol use, which sets it aside from adults.

This thesis found differences in neuropsychological function in the areas of attention and memory in adolescents who were characterised as higher risk drinkers. The findings both support and contrast with previous studies, which further highlights, the disparity and research gap in this area. Notwithstanding, distinctions albeit small, can be used to inform future research which builds on the current understandings of neuropsychological function and development in adolescents who use alcohol.

Underlying subgroups of adolescent's, characterised by a limited number of drinking indicators, were found to be associated with a range of harms, and these latent class models could be generalised to wider adolescent population groups. This conceptualisation of young people can provide new information on underlying, unobserved variables pertinent to this population group, who may just be embarking into experimentation with alcohol.

Alcohol screening and assessments should continue to be widely supported in ED and school settings, and where possible, greater consistency and detail in drinking patterns beyond the standard quantity-frequency aspect should be obtained. This is likely to further understanding and insight into how drinking typologies or profiles may present, at a time when a young person may be making decisions around their future course. This should inform how policy, health education, assessments and interventions can be best placed during this critical developmental period.

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